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CODE TELEGRAMS.

THE introduction of the sixpenny rate for telegrams in this country has given rise to many suggestions by which the public may obtain the very fullest value for their money. Although these suggestions are hardly a logical sequence of the recent change, for most of them would have applied with equal force in the case of shilling telegrams; yet the mere fact of a change having been made has been sufficient to arouse attention and to stimulate dormant ideas. It is hardly probable that the Postal Department will themselves undertake the formation of a code, seeing that this would involve an expense which would not only yield no return, but would tend to decrease the revenue. At the present time several code books exist which might be more generally used than at present, and which would in all probability be used, were not their price practically prohibitive to the general public, and their dimensions far too great. A code book for general use must be a pocket-book, in the literal meaning of the expression, and must be priced accordingly. The registration of addresses, which has very freely been taken advantage of by commercial firms, and to some extent by the public, is a form of coding which is a legitimate part of the work of the Postal Department, and would probably be much more taken advantage of if the registration fee were reduced; which course would not, we think, prove other than an increased source of profit to the Post Office, even if the reduction in the number of words of which a telegram so coded would consist, is allowed for. The universal adoption of an international code is a consummation hardly to be expected, valuable as such a code to the public, but not to telegraph companies, would undoubtedly be.

AMERICAN TELEPHONE PATENTS.

THE explanation we spoke of last week as being desirable regarding the origin of the action by the United States Government against the American Bell Telephone Company, has been given by Mr. Van Benthuysen, president of the National Improved Telephone Company, and also by the "friends" of Mr. Garland, the Attorney-General, who was said to be largely interested in an opposition telephone company—in fact, the most successful company which has opposed the Bell interests, the Pan Electric—which has numerous and large exchanges in some of the Southern States. Both these authorities assert that Mr. Garland is innocent of all connection with what was done, and fairly done, as they claim, by his deputy in office, he himself being away for his vacation. This, if accepted, may broadly acquit Mr. Garland of any unfair use of his power and influence; but there are other facts, or what are stated to be facts, still remaining of which it would be better to have some explanation. It would be interesting to learn why the custom of remitting the application to the Commissioner of Patents for decision was not observed, and also whether it is usual for the acting Attorney-General, or any other subordinate in a corresponding position, to take such an exceptional step without consulting his chief.

From exchanges we gather that there is a consensus of opinion that this will be the most important of the many actions in which the Bell Company has figured, and the trial is awaited with strong and general interest. Mr. Van Benthuysen, who has been the moving spirit in this latest development of telephone history in the States, appears confident from his utterances. He occasionally uses very strong language when speaking of the Bell people, as witness the following extract from a recent speech of his:—"The Bell attorney threatened me with serious consequences for attacking the validity of the Bell patents, and then lied about it, and now they object to being made defendants in a court of justice, wherein there will be no opportunity for their peculiar tactics, which make them more dangerous to the liberties of the people than a standing army." Another remark made by Mr. Van Benthuysen is not unworthy of notice. He says: "If Mr. Garland had been present and had refused to grant permission because of his personal relations to another telephone company, it would have been a great wrong and imposition that he should permit his private affairs to prevent his performing a duty to the public." He is determined to leave no opportunity neglected to achieve his ends, and his last action in that direction has been to appeal to the President of the United States, "to see that no further wrong is done," presumably in allusion to the accusations made against the Attorney-General.

Electric Lighting at the Leicester Exhibition.—One of the chief features in connection with the Health Exhibition at the Floral Hall, Leicester, is the lighting of the hall by electricity, which has been successfully carried out by Messrs. Woodhouse and Rawson. The main hall of the building at Leicester is brilliantly lighted by five arc lamps of 4,000 C.P. each, arranged in a row down the centre of the hall; in the *annexe* are two more of these lights, and another is placed outside the building, where it proves a great source of attraction to persons passing by. The arc lamps used are the Crompton-Crabbe, and, as is usual where this well known lamp is used, give perfect satisfaction. The incandescent lamps are run off an Elwell-Parker machine of their recent type. The incandescent lamps, of which there are forty of the Woodhouse and Rawson type, are used with a good effect upon the different stalls, the most noticeable being those used in the ventilating shaft of the Æolus Water Spray and General Ventilating Company, where the water plays right over them. One of Messrs. Marshall and Sons' portable engine of 12 nom. H.P., and fitted with Hartnell's patent automatic expansion gear, drives the lamps perfectly steadily.

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THE BRITISH ASSOCIATION.

(Specially Reported for the "Electrical Review.")

ON THE SENSITIVENESS OF SELENIUM TO LIGHT, AND THE DEVELOPMENT OF A SIMILAR PROPERTY IN SULPHUR.

By SHELFORD BIDWELL, M.A., LL.B.

(Section B.—Chemical Science, September 14th.)

THE remarkable property apparently possessed by crystalline selenium of having its electrical resistance varied by the action of light, a property which was first announced by Mr. Willoughby Smith in 1873, has been the subject of many investigations. Of these the best known, and by far the most exhaustive, are the researches of Prof. W. G. Adams and Mr. R. E. Day, an account of which is published in the *Phil. Trans.* of 1877. As the result of numerous experiments, these gentlemen were led to form the opinion that "the electrical conductivity of selenium is electrolytic." The principal reasons given for this conclusion are:—(1) that the resistance of the selenium bars used appeared to depend upon the electromotive force of the battery employed, being generally diminished as the battery power was increased; (2) that the resistance of a bar A B was generally not the same for a current in the direction A B as for a current in the direction B A; (3) that the passage of a battery current was always followed, when the battery had been disconnected, by a secondary or polarisation current in the opposite direction, it being clearly proved that this secondary current was not due to any thermo-electric action, either in the selenium itself or in an other part of the circuit.

The authors do not, however, appear to have considered that the observed behaviour of selenium was to be explained by actual electrolysis, but rather that the molecular structure or crystalline condition of the substance was altered or modified by the action of a current of electricity in such a manner as to produce effects analogous to those which would have occurred if the selenium were an electrolyte and actually decomposed by the current. As to the possible influence of light, the following are their words:—"Light, as we know, in the case of some bodies, tends to promote crystallisation, and when it falls on the surface of such a stick of selenium, tends to promote crystallisation in the exterior layers, and therefore to produce a flow of energy from within outwards, which, under certain circumstances, appears in the case of selenium to produce an electric current. The crystallisation produced in selenium by light may also account for the diminution in the resistance of the selenium when a current from a battery is passing through it, for, in changing to the crystalline state, selenium becomes a better conductor of electricity."

Attention has lately been again directed to the subject of selenium, and its behaviour under the influence of light, by the publication, by Mr. C. E. Fritts, of New York, of a new and extremely ingenious method of constructing selenium cells. He melts a thin film of selenium upon "a plate of metal with which it will form a sort of chemical combination. . . . . During the process of melting and crystallising the selenium is compressed between the metal plate upon which it is melted and another plate of steel or other substance with which it will not combine. . . . . The non-adherent plate being removed after the cell has become cool, [he] then covers that surface with a transparent conductor of electricity, which may be a thin film of gold leaf. . . . . The whole surface of the selenium is therefore covered with a good electrical conductor, yet is practically bare to the light, which passes through the conductor to the selenium underneath." The sensitiveness to light of cells constructed in this manner seems to be far in excess of anything that has been previously obtained; and the "photo-electric" currents which (like the selenium bars of Messrs. Adams and Day) they are capable of originating, are said to be strong enough to be actually useful in practical work.

It is impossible to read Mr. Fritts's paper without being impressed by the resemblance of some of the phenomena which he describes to those of electrolysis. The mere arrangement of the apparatus—two metallic plates with a third substance between them—is in itself strongly suggestive; while the unequal resistance offered by the two surfaces, and the generation of an independent electromotive force, in conjunction with the polarisation effects above referred to,* make it hard to believe that the conduction of selenium (in the form used in experiments) is not truly and literally electrolytic.

The only considerable difficulty in the way of this hypothesis arises from the fact that selenium is not an electrolyte. Ever since its discovery in 1817, selenium has been regarded as an element, and very strong evidence indeed would be necessary to deprive it of its elementary character; this is perhaps the reason why the electrolytic theory has not previously been proposed. But there is a possible way out of the difficulty, which was suggested to me by the first words in the above quotation from Mr. Fritts's paper. He spreads the selenium upon a plate of metal *with which it will form a chemical combination.* Now selenium will, I believe, combine more or less easily with all metals, forming selenides; and in experiments upon the conductivity of selenium, it has been usual to submit the substance to prolonged heating in contact with metallic electrodes. This prolonged heating (generally followed by slow cooling) has hitherto been called "annealing;" and the undoubted fact that it diminishes the specific resistance of the selenium and increases its sensitiveness to light has been explained by supposing that the process is favourable to perfect crystallisation.

I venture to suggest, as the true explanation of the effect, that heating is favourable to a chemical combination between the selenium and the metal forming the electrodes, that a selenide is thus formed which completely surrounds the electrodes, and is perhaps diffused to some extent throughout the mass of the selenium;* and that the apparently improved conductivity of the selenium, together with the electrolytic phenomena which it exhibits, are to be accounted for by the existence of this selenide.

I have sometimes been tempted to think it possible that the apparent conductivity of selenium may in fact be *entirely* due to the impurities which it contains, and that perfectly pure selenium would be as good an insulator when in the crystalline form as it is in the vitreous condition. Vitreous selenium might contain a large percentage of conducting particles without sensible increase of its conductivity, but that this would not be the case with crystalline selenium is rendered more than probable by the results of some experiments which I have described in a former communication. If a conducting powder, such as graphite, is mixed with melted sulphur, even in small proportions, the mixture when cold is found to conduct electricity; while if a very large proportion of the same powder is incorporated with melted shellac, the shellac when cold remains sensibly as perfect a non-conductor as if it were pure. The explanation which I have given of these facts, and in support of which a number of experiments are quoted, is as follows:—The first mixture does not consist of a uniform structureless mass of sulphur, having particles of carbon imbedded in and completely surrounded by it; it is in fact an aggregation of little crystals of sulphur with carbon packed between them like mortar between bricks. The conduction thus takes place entirely through the carbon particles, which may be considered as extending in a series of chains from end to end of the mass. In the case of the shellac mixture, though the proportion of carbon may be larger than in the sulphur experiments, the resistance is still sensibly infinite, because the structureless shellac penetrates between and completely surrounds the carbon particles. Just in the same manner selenium, when in the vitreous condition, would completely surround any particles of conducting selenides which it might contain; while, when the selenium was crystallised, the conducting particles would arrange themselves in the form of a network, capable of conveying a current of electricity.

Selenium which is free from impurities appears not to be an article of commerce. An analysis of samples collected by Prof. Graham Bell from different parts of the world disclosed the presence of the metals iron, lead, and arsenic,† all of which would form conducting selenides. Nevertheless, I thought it would be worth while to ascertain roughly the specific resistance of a piece of selenium which, since it has come into my possession, has never been in contact with metal. The selenium (which was supplied by Messrs. Hopkin and Williams) was melted in a mould built up of slips of glass, crystallised and "annealed" in the usual way; but, contrary to the general practice, it was *not* fitted with metallic electrodes before annealing. A plate of crystalline selenium was thus formed, having a thickness of about 2 millim. and a superficial area of 1 square centim. The two opposite surfaces were rendered smooth and clean by rubbing them upon a flat board covered with fine glass-paper, and the plate was placed between two layers of thick tinfoil which were pressed into good contact with it by a weight of 500 grammes. When this arrangement was connected in circuit with 6 Leclanché cells and a reflecting galvanometer, a deflection was produced indicating a current of about $\frac{1}{10}$ micro-ampère. Assuming the electromotive force of the battery to have been 10 volts, the resistance of the plate would be 500 megohms; and therefore the resistance of a cubic centimetre of the selenium between opposite faces (*i.e.*, its specific resistance) would be 2,500 megohms. From the dimensions and resistance of a good selenium cell with copper electrodes, which I have in my possession, I calculated that the specific resistance of the selenium contained in it was about ·9 megohm. Thus, so far as the result of a single rough experiment can be trusted, it appears that the conductivity of selenium which has been annealed in contact with copper is nearly 3,000 times greater than that of selenium which has undergone similar treatment without the presence of a metal. Whether selenium, when perfectly pure, is altogether a non-conductor, would be an interesting question for an expert chemist to determine.‡ It is sufficient for the theory which I am at present advocating, that its specific resistance should be very high.

By assuming the admixture with the selenium of metallic selenides, an explanation is afforded of the following facts:—

(1) The diminished resistance produced by annealing.

(2) The fact, first pointed out by Graham Bell, that the resistance of selenium appears to depend greatly upon the nature

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* "The existence of polarisation," says Clerk Maxwell, "may be regarded as conclusive evidence of electrolysis." "Electricity," vol. i., p. 363.

* The selenium is necessarily for some time in a liquid state.

† Paper read before the National Academy of Sciences, April 21st, 1881.

‡ On more mature consideration I am inclined to think that it is not.

of the metals of which the electrodes are formed. For obtaining low resistance he recommends the use of brass in preference to platinum, and expresses his belief that the chemical action between the brass and selenium contributes to the low resistance of his cells, "by forming an intimate bond of union between the selenium and brass."

(3) The fact observed by Adams and Day that there is generally a "diminution of resistance in the selenium as the battery power is increased." The same phenomenon occurs in the mixtures of sulphur and carbon before referred to. It points to the existence of imperfect contact between conducting particles, the conduction partaking of the nature of disruptive discharge, and is consistent with the supposition that particles of conducting selenide are imbedded in the selenium.

(4) The apparent production by a current through a piece of selenium of a "*set* of the molecules which facilitates the subsequent passage of a current in the opposite, but obstructs one in the same direction." This would be accounted for by the electrolytic deposition of selenium (from the selenide) upon the anode.

(5) The polarisation effects, which would also proceed from electrolysis.

(6) "A slight increase of temperature of a piece of annealed selenium is accompanied by a large increase of electrical resistance." This also occurs in the mixture of sulphur and carbon, and is explained by supposing that the heat expansion of the medium draws apart the conducting particles contained in it, causing them to have fewer points of contact with each other, and thus increasing the resistance of the whole. A more considerable rise of temperature so greatly diminishes the specific resistance of the selenide (and perhaps of the selenium) as to more than counterbalance this effect; and thus it happens (as I have shown in a former communication) that selenium cells have a "temperature of maximum resistance," which is generally a few degrees above the average temperature of the air.

(7) The resistance of prepared selenium is generally greatly diminished by the action of time. Prof. Adams found that the average resistance of a number of pieces of selenium was reduced to less than one-fortieth in the course of a year. During this period the selenium had been in contact with the metallic electrodes; and it seems possible that a larger quantity of selenide than was produced in the first instance by the process of annealing was slowly formed. This would especially occur at the "marked end" or anode, where there would naturally be a quantity of free selenium.

In the above argument it has been assumed that selenium will combine directly with any metal with which it is brought into contact, the combination being facilitated by the application of heat. In the case of such metals as copper, brass, and silver this is undoubtedly the fact. Indeed, an attempt to make a selenium cell with silver wires was attended with failure in consequence of the complete destruction of the metal after contact with the melted selenium for only two or three minutes. It is, however, questionable whether platinum (which was the metal used by Adams and Day) is, in any sensible degree, attacked by selenium either at the ordinary temperature or at that reached in the process of annealing. With sufficient heat the two substances will undoubtedly unite; and I have found that the surface of platinum-foil upon which melted selenium has been kept for an hour or two at a temperature probably of about 250° C. acquires a bluish-grey colour which may be due to selenide. But whether any appreciable quantity of selenide is formed in the ordinary preparation of crystalline selenium is a question only to be settled by the aid of refined chemical operations which I am incompetent to undertake, and in the meantime the suggested theory is left without direct confirmation.

But certain indirect evidence in support of my views has been forthcoming. Selenium is an element which, in its properties, closely resembles sulphur, and attempts have from time to time been made, hitherto without success, to develop in sulphur that peculiar sensitiveness to light which is such a remarkable characteristic of selenium. It occurred to me that if this property of selenium were really due to the accidental existence of metallic selenides, then the admixture with sulphur of metallic sulphides might be expected to lead to similar effects. It is not possible to "anneal" a stick of sulphur or a sulphur "cell" previously furnished with metallic electrodes, because sulphur does not, like selenium, solidify and crystallise at a higher temperature than that of its first melting point. But if it is true that the virtue of annealing really lies in the fact that a chemical union of the two elements is promoted by the action of heat, it is clearly immaterial whether the substances are heated together before or after the formation of the cell. Sulphur containing sufficient metallic sulphide to render it a conductor of electricity might be used in the construction of a cell which might be expected to be sensitive to light without any preliminary annealing. This turned out to be actually the case.

Silver was the metal chosen for the experiments on account of the facility with which it combines with sulphur.

Cell No. 1.—Five parts of sublimed sulphur and one part of precipitated silver were heated together in a porcelain crucible for about two hours. The mixture was from time to time stirred with a glass rod and was finally allowed to settle, so that the bulk of the sulphide and any free silver which might remain fell to the bottom of the crucible. When the temperature was slightly above the melting point the liquid sulphur, which was perfectly mobile, though black with minute suspended particles of sulphide, was poured off for use. Two fine wires of silver* were then coiled side by side around a strip of mica 50 millim. long and 27 millim. wide; the wires were about 1 millim. apart, and care was taken that they did not touch each other at any point. Some of the melted sulphur was spread evenly over one surface of the mica, the two wires being thus connected with each other through half their entire length by a thin layer of the prepared sulphur. When cold, this cell was connected in circuit with a battery and a galvanometer. It was found to conduct electricity, but its resistance was very high, being probably between 20 and 30 megohms. With the object of partially bridging over the intervals between the wires, the sulphur was melted by laying the cell upon a hot plate, and a piece of very thin silver-foil, measuring 25 millim. by 10 millim., was laid upon its surface; this was probably entirely converted into sulphide before the cell was again cold. The cell was now found by a bridge measurement to have a resistance of 900,000 ohms.† Once more it was connected with a Leclanché cell and a suitably shunted galvanometer; the deflection was noted, and a piece of magnesium wire was burnt at a short distance from the sulphur. The deflection was immediately more than doubled; and when the magnesium was extinguished, the spot of light at once returned to very nearly its original position. The effect was almost as great when a glass trough containing a saturated solution of alum was interposed between the sulphur and the burning magnesium.

Now it is well known that the resistance of sulphide of silver is greatly diminished by heat, and it was therefore important to ascertain whether the effect just described was due to light or to heat. To speak more accurately—Is it an effect of *radiation* or of *temperature*? Exposure to radiation, whether visible or invisible, is of course always accompanied by a certain rise of temperature, and confusion has sometimes arisen, especially in discussing the properties of selenium, from failure to distinguish between the direct effects of radiation, and the indirect effects which are primarily due merely to a rise of temperature. In the photographic processes it is radiation *per se* that produces the observed results; in the best known processes, the effective rays happen to be those which correspond to the most refrangible part of the visible spectrum together with the invisible rays beyond it. But by more recently discovered methods the "obscure heat rays," as they are sometimes called, have been made available for photographic purposes‡; and these do not act by virtue of any rise of temperature which they may cause, but exert direct chemical action upon the sensitised plate. Again, if a thermo pile is exposed to radiation, an electromotive force is generated. Here, however, the effect of radiation is indirect; it acts only through the medium of the heat which it produces; and if an equal and similarly distributed amount of heat were communicated to the thermo-pile by any other means (as by conduction), exactly the some effect would follow. In an ordinary selenium cell radiation acts both directly and indirectly, tending to produce opposite effects. The direct effect of the radiation, whether it be visible or infra-red or ultra-violet, is a diminution of the resistance of the cell; at the same time the radiation slightly raises the temperature of the cell, and so indirectly tends to increase its resistance. If a selenium cell in circuit with a battery and a galvanometer is suddenly exposed, by withdrawing a screen, to the radiation of a black-hot poker, a momentary swing of the galvanometer magnet will at first indicate a fall in the resistance; but this will be almost immediately followed by a rise which will increase up to a certain limit as the temperature of the cell becomes higher. The same kind of thing occurs when the cell is exposed to the infra-red or red portions of the spectrum; but in the latter case the temperature effect merely diminishes, instead of overpowering, that directly due to radiation. If the bridge method is used for measuring the resistance, it may easily happen that the effect of gradually rising temperature escapes notice, a balance not being obtained until the temperature has become constant; and thus probably, is to be explained the fact that different observers have attributed the most powerful action upon selenium to different parts of the spectrum, ranging from infra-red to greenish yellow.

The resistance of the sulphur cell, which has been described, unlike that of most selenium cells, was diminished by a rise of temperature.§ When in circuit with a Leclanché cell and a galvanometer, the effect of holding a nearly red hot brass rod at a distance of 3 centim. from its surface, was a gradual fall of resistance, which in 15 seconds was indicated by 23 scale-divisions. When the rod was removed, the spot of light slowly returned to its original position, occupying several seconds in doing so. It is certain that the temperature of the sulphur must in this experiment have been much higher than when it was exposed to burning magnesium, with a solution of alum interposed, yet the effect was very much smaller; moreover, it was gradual instead of instantaneous.

Another experiment seems to prove conclusively that the resistance of the cell is diminished by the direct action of radiation, quite apart from any effect which may be produced by an inci-

* Supplied by Messrs. Johnson and Matthey.

† This resistance was afterwards found to be very variable, and it was never the same with a direct and a reverse current.

‡ Captain Abney is said to have obtained a photograph of a kettle of boiling water by means of the invisible radiations which it emitted.

§ This was not so with all the cells subsequently made. See description of cell No. 3 below.

dental rise of temperature. On a cloudy day the cell, with the alum trough before it, was placed at a distance of 16 feet from a small window, all the other windows in the room being darkened. With the same battery and galvanometer as before, it was found that closing the window shutter caused an instantaneous swing of the spot of light through 90 scale divisions in the direction indicating increased resistance; and when the shutter was again opened, there was immediately an equal swing in the opposite direction. A delicate thermo-pile of 54 pairs, connected with an astatic reflecting galvanometer of low resistance, was then put in the place of the sulphur cell, and the alum trough placed before the open end of the conical reflector attached to it. On opening the window shutter, a deflection occurred indicating a current which was found by trial to be equal to that produced by the radiation of the human body at a distance of 10 ft. 6 in. It is needless to say that such a minute change of temperature as this implies was without sensible effect upon the resistance of the sulphur cell. There can then be no doubt whatever that the whole of the observed effect of the light upon the sulphur was due to the action of radiation as such, any change of resistance resulting from the incidental rise of temperature being quite inappreciable.

Cell No. 2.—This was constructed in a somewhat different manner. A piece of silver foil was laid upon the surface of the mica before the two wires were wound round it, and instead of having prepared sulphur spread upon one face, the whole was immersed in *pure* melted sulphur for a few minutes, and then carefully drained. Before this treatment the silver wires were of course short-circuited by the foil, but the liquid sulphur penetrated between them, forming a film of sulphide; and when cold, the resistance of the cell was about 100,000 ohms. Though this cell turned out to be somewhat less sensitive than the other, it seemed likely that, on account of its comparatively low resistance, it might be successfully used for a photophonic experiment. It was therefore connected in circuit with a battery of 10 Leclanché cells and a telephone, and exposed to a rapidly interrupted beam of light. The telephone at once gave out a musical note, which was nearly as loud as that produced by a good selenium cell under similar circumstances.

The behaviour of this cell under changes of temperature was the same as that of the other.

Cell No. 3.—A mixture, consisting of equal parts of sublimed sulphur and precipitated sulphide of silver, was melted and spread on one surface of a slip of mica, around which two silver wires had been wound as before. No foil was used in this case. The resistance of this cell was diminished by radiation, but increased in a very marked manner by rise of temperature. A paraffin lamp, at a distance of 18 inches, produced a steady diminution of the resistance. When the lamp was placed at a distance of 10 inches, the galvanometer needle first moved in a direction indicating a further fall of resistance; but after a few seconds, when the temperature began to rise, it turned in the opposite direction. On moving the lamp 6 inches nearer, there was at once a large deflection in the direction of increased resistance, the temperature effect completely predominating over that of radiation.

Cell No. 4.—A strip of silver leaf was attached to a glass plate by means of gold size, and the middle part of it was exposed to the vapour of boiling sulphur until both surfaces were completely blackened. The resistance of this cell was high, but for a few days it was extraordinarily sensitive, a reflected beam of sunlight instantly effecting a diminution of 80 per cent. in its resistance. About a fortnight after it was made its sensitiveness had greatly fallen off.

All these cells resemble selenium in giving polarisation currents after being detached from the battery.

Supposing it to be true, then, that it is not in the selenium or sulphur itself, but in certain metallic selenides or sulphides, that the sensitiveness to light is resident, does it become easier to explain the phenomenon or, rather, to deprive it of the unique position which it has hitherto appeared to hold, and assign to it a place among a class of analogous effects?

I believe that, at all events in the case of the sulphur silver cell, it is principally at the surface of the *electrodes* that the effects of radiation are to be looked for.

If a current of electricity is passed through a mass of sulphide of silver having silver electrodes, silver will be deposited upon the cathode and sulphur upon the anode. The accumulation of silver upon the cathode will clearly produce no appreciable effect upon the conductivity of the arrangement, and need not be considered. But sulphur has an enormously high resistance, and the deposition of a mere film of free sulphur upon the anode would be sufficient to stop the current altogether. The current is not in fact stopped, because the deposited sulphur at once combines with the silver of the anode, merely adding a new layer to the electrolyte. Thus the metal of the anode gradually combines with the sulphur of the electrolyte, and the conductivity of the arrangement will depend to a great extent upon the facility with which this combination is effected, the quantity of electricity which can pass in a given time being limited by the quantity of sulphur which is capable of uniting with the electrode in the same time.

Sulphur combines with silver far more readily than with iron. If, therefore, my views are correct, we should expect a cell with an iron anode to offer a much greater resistance than one which had an anode of silver, the material of the cathode, so long as it was a good elementary conductor of electricity, being of comparatively little importance. To test this idea, a cell was made consisting of electrodes of iron and silver imbedded in a mixture of sulphide of silver and sulphur. The cell being connected with a battery and a galvanometer, the deflection was 115 divisions when the current passed from the silver to the iron through the electrolyte, and only four divisions when the direction of the current was from iron to silver.* The resistance was therefore nearly 30 times as great with an an iron anode as with a silver anode. It is clear that this was not the result of bad contact between the iron and the electrolyte (such as was supposed by Graham Bell in the analogous case of selenium to account for the high resistance of a cell with platinum electrodes as compared with one in which the electrodes were made of brass), because such an effect would be independent of the direction of the current. Rather it seems that the resistances of the two anodes afford data for measuring the relative facilities with which sulphur combines with silver and with iron.

Assuming it to be thus experimentally proved that the resistance of a sulphur-silver cell depends largely upon the readiness with which sulphur unites with the anode, it follows that any cause which would assist this union would at the same time diminish the resistance. Now it is well known that certain chemical combinations are accelerated by the action of radiation—the explosive union of chlorine with hydrogen under the influence of sunlight being a familiar example. The question then suggests itself, Does sulphur combine with silver more readily when exposed to radiation than it otherwise would? There is, I believe, direct evidence that it does.

A glass plate, covered with silver leaf, was placed, with the silvered side downwards, over a crucible of boiling sulphur. One half of the plate was covered with a piece of black cloth, and the arrangement was exposed to bright sunshine. In a short time the visible portion of the silver was darkened, owing to its partial conversion into sulphide; the cloth was then removed, and the silver beneath it was found to be scarcely discoloured. There was a distinct line of demarcation between the two halves. The experiment was repeated with the same result.

Since this effect might possibly have been due to other causes than the action of light (such as the unequal condensation of sulphur vapour upon the covered and uncovered portions of the plate), the experiment was made in another form. A piece of silver leaf attached to glass was brushed over with a solution of sulphur in bisulphide of carbon; and in order to keep the temperature low and uniform, the silvered glass plate was immersed in a basin containing cold water, which was placed in the sunshine. A board was laid across the top of the basin so as to shade one half of the plate, the other half being exposed to the direct rays of the sun. In a quarter of an hour the exposed portion of the silver had acquired a dark brown colour, while that which had been protected was of a pale yellow tint, the outline of the shadow of the board being sharply defined. I think we have here the strongest evidence that the combination of sulphur with silver is assisted by radiation.

But it is not perhaps necessary to assume that the effective action of light is confined entirely to the surface of one of the electrodes. If, as is commonly believed, electrolytic conduction involves a series of decompositions and recompositions throughout the electrolyte, any cause which assists either the separation or recomposition (or both) of the components of the electrolyte might be expected to increase its conductivity; and it seems reasonable to suppose that the same influence which would assist the union of two substances when they have a tendency to unite would also be favourable to their separation when they have a tendency to separate. It is not impossible, therefore, that radiation, acting upon the surface of a thin layer of sulphide of silver through which an electric current is passing, might, by facilitating the molecular rearrangement of the atoms of sulphur and silver, exert a material influence upon the conductivity of the sulphide.†

So far as regards the explanation of the effect of light upon the resistance of selenium, I am aware that this paper contains little more than speculative suggestions, which are at present almost entirely unsupported by experimental evidence.‡ It is, however, noteworthy that these speculations led to the construction of a cell which, without containing a particle of selenium, behaved almost exactly as if it were composed of that substance. How far this may be considered to prove anything with regard to selenium I do not know; but in any case the discovery of another substance possessing the same remarkable property seems in itself to be a matter of some interest.

[This paper was also read before the Physical Society in May last, and was published in the *Phil. Mag.* for August.]

DISCUSSION.

Prof. CRUM BROWN said they were very much indebted to Mr. Bidwell for this paper, because while the physicists were taking away so much of chemistry and making it into physics, it was encouraging to see them giving a chemical explanation of what was a powerful physical phenomenon. Although he had not

* The resistance of the galvanometer was 3,483 ohms, and it was shunted with a coil of 20 ohms. The resistance of the Leclanché cell was about 5 ohms.

† There are some experimental reasons, into which I am not at present prepared to enter, for believing that the admixture with the sulphide of a certain amount of free sulphur is necessary for the development of sensitiveness to radiation.

‡ It is especially desirable to ascertain experimentally whether the combination of selenium with the metals used as electrodes in selenium cells is assisted by light.

exactly proved what took place in a selenium cell, the generalisation of it lent great penetrating power to his argument. They were not logically bound to believe the theory which led to it, but it certainly drew their attention very closely to it and gave it a very great deal of probability. The question suggested as to the way in which light acted in favouring the chemical action of a great many substances was one of extreme interest, but it was not easy to see at present how more could be done than to speculate in the dark on the subject of the action of light.

Prof. DEWAR said with reference to the electric action of light, he had with Dr. Kendrick on several occasions tried to imitate the effects of that action by means of a fluid cell. They also tried all kinds of photographic methods, but in no case could they trace any kind of electric effect, except when they could easily prove that chemical decompositions were associated with it. They proved that the sensibility of the cell depended upon the intensity of the light, and that it also varied very much with the concentration and rapidity of diffusion.

Prof. LODGE said Mr. Bidwell's experiments were most interesting, and, although he was not able to discuss them, anything which threw any light upon what light does, was of great importance. The action of light on selenium had engaged his attention, but he had not come to any conclusion. Now Mr. Bidwell had obtained a clue, he hoped he would follow it out.

ON THE B.A. STANDARD GAUGE FOR SMALL SCREWS.

By EDWARD RIGG, M.A.

(*Section G.—Mechanical Science, September 15th.*)

AT the suggestion of the Mechanical Section, a committee was appointed by the British Association at Southampton, in 1882, for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes. This committee presented its final report at the Montreal meeting, and it will be of interest to the section to know that progress has already been made towards the general adoption of the standard series of screws then recommended.

They have been officially adopted by the Telegraph Department of the Post Office, and this step alone may be relied upon to ensure their general adoption by telegraphic and electric instrument trades in the course of a few years. The entire series of standard taps and dies has not yet been manufactured, but such as have been completed are now on view at the Inventions Exhibition, where they have been awarded a diploma by the Jury Commission.

It will naturally be more difficult to secure their general introduction throughout the clock and watch making and other analogous industries; but important help may be expected in reference to these branches from the fact that in Switzerland, where the system adopted by the B.A. originated, an identical series of screws has already secured the support of the leading manufacturers, and the plates and finished screws will shortly be placed in the market.

OPTICAL THEORIES.

(*Section A.—Mathematical and Physical Science, September 15th.*)

MR. GLAZEBROOK, who read a paper on this subject, concluded his communication with a section dealing with Maxwell's electromagnetic theory of light, the section being as follows:—

Electro-magnetic disturbance travels in air with a velocity equal to that of light, and in a double refractory medium obeys Fresnel's laws. The difficulty lies in giving a physical explanation of light motions and of accounting for the mechanical structure of the ether required by the theory. No complete theory of dispersion has yet been given. The work of Willard Gibbs does not explain why there is no dispersion in a vacuum. The objection made to Cauchy's theory holds good. It is probable that some theory such as is developed in the third section may be successfully applied to the electro-magnetic disturbance. The theory has the great advantage of connecting naturally with the theory of light the important electro and magneto optical discoveries of Faraday, Herr Kundt, and Quincke, and to the development of this much is due to Prof. Fitzgerald. The theory of reflexion and refraction as at present developed is only approximate.

COPPER RESISTANCE BY FALSE-ZERO METHOD.

By EDWARD RAYMOND-BARKER, Brazilian Submarine Telegraphs.

(*Concluded from page* 312.)

The taking of the weekly routine copper resistance test of a submarine cable by means of the false-zero method is a very simple operation. The operator may proceed as follows:—Unplug the desired ratio at a and b, and if an equal ratio be employed—say, 1,000 : 1,000 —proceed to unplug at R a resistance as nearly as possible equivalent to that of C; or if C be too high to be conveniently balanced with an equal bridge ratio, let $a = 100$ and $b = 1{,}000$, in which latter case a resistance must be unplugged at R equal to $\frac{1}{10}$ of C, that is, R must be to C as a is to b. (The approximate C.R. of a cable is always known, so the requisite resistance may be unplugged at R without delay and without the preliminary test to scale zero, which would be necessary were C to be an utterly unknown resistance value).

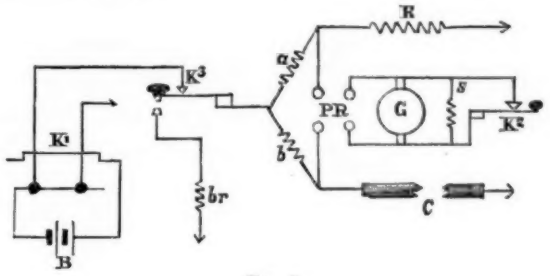


FIG. 3.

a, b, and R having been thus adjusted, depress K^3 and open short circuit key, K^2, G being conveniently shunted by S (vide fig. 3) in such a way as to increase the range of the deflection as far as is compatible with the scale limits. Note scale reading, which is the false zero, and short circuit G. Raise K^3 and apply, say, zinc current at K^1. After a lapse of some seconds, open K^2. The deflection on the scale will now be about the same as before; if not, it will be found that the addition or subtraction of one or two *units* at R will suffice to balance to the false zero. This being done, note resistance at R as first value, Z to L. Short circuit G, and reverse B at K^1, thus applying the copper current to bridge and cable. Open G, and if the deflection be not exactly what it was in the former instance, make the requisite adjustment at R by adding or subtracting a unit or two as the case demands, thus reproducing the false zero. The resistance Z to L (R') and C to L (R'') will be found almost exactly the same if not quite. Should, however, the two values not exactly coincide, unplug the mean of the two at R as balancing resistance to C. Note false zero afresh, as above, and then take another series, Z to L and C to L alternately in the usual way, when R' and R'' will come out equal and the formula $C = \frac{b}{a} R'$, or $C = \frac{b}{a} R''$ will be correct. In most cases the earth current remains fairly constant throughout the test. Should it vary at all, the false zero should be re-observed as often as the occasion requires.

In practice it is advisable to throw the "spot" to one end of the scale for scale zero and to adjust the galvanometer shunt (S) for the false zero deflection to extend across the entire scale, for the larger the deflection, the more sensitive becomes the test. Fig. 3 shows how a pole-reverser (P R) may also with advantage be introduced between the galvanometer and bridge terminals, so that both *positive* and *negative* earth currents can be made to deflect the "spot" in one given direction, for it may often happen that the operator has to take successive tests of cables lying in opposite directions, the apparent direction of the earth currents, of course, likewise varying.

If "slides" be used, connections may be as in fig. 4. When false zero is being noted, the double sliding contact is placed at 50, the single sliding contact at 0, the slide reading being 5,000. In order to obtain similar slide readings with both currents, when C is traversed by an earth current, R must be approximate to C, and the nearer R approximates to C, the greater will be the similarity between the slide readings, Z to L, and those, C to L; but even if R be not made approximate to C, and whatever be the resistance given to R, working to false zero will render the Z to L and C to L values far more uniform than would the ordinary scale-zero method.

Figs. 5, 6, and 7 constitute a geometrical proof of the false-zero test, according to the well-known right angled triangle method, horizontals representing *resistances*; perpendiculars representing *potentials*, and hypothenuses *falls of potential*.

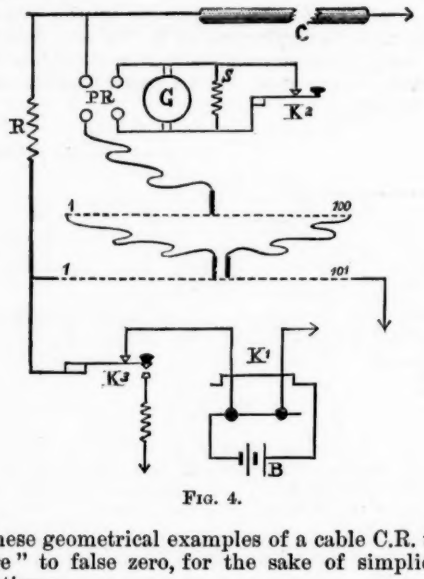


FIG. 4.

In these geometrical examples of a cable C.R. test by "bridge" to false zero, for the sake of simplicity of illustration :—

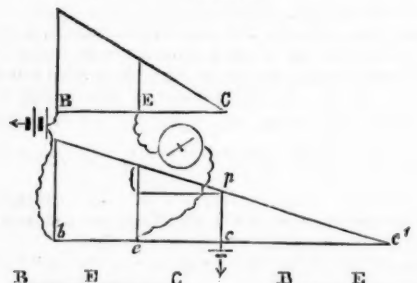
1. The four branches of bridge are equal.
2. Testing battery = 2 cells.
3. E.M.F. of earth current = 1 cell.

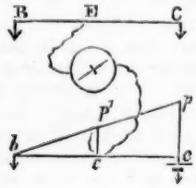
In figs. 5. 6, and 7 let B, E and b, $e = m$ and m' respectively, two equal ratio resistances.

Let E, C = R = unplugged resistance to balance x.

Let e, $c = x$ = resistance of a cable into which is flowing at distant and a *positive* earth current of a potential, c, p, at point c, of 1 cell.

FIG. 6.





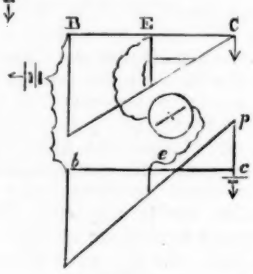


FIG. 5. FIG. 7.

In case in point, $m = m' =$ R $= x =$ say, 1,000 ohms.

Fig. 5 represents condition of things before application of battery, and when m and m' are direct to earth through key, or with b r, inserted if required. Perpendicular, e, p', shows potential of earth-current at point e equal in the present instance to pot. of ·5 cell. Connection being made through G between e and E, a + current due to the joining of these two points at unequal potentials traverses G from e to E, and produces a deflection of, say 100 divs. of scale—say to the right of scale zero. It is apparent that if any alteration be made, either now or after the application of battery, in the resistances, m, m', or R, a corresponding alteration will be brought about in the range of the above-mentioned deflection.

Fig. 6 shows condition of things with the + pole of battery applied to bridge. Perpendiculars at B, E, b, e, c, show potentials at same said points.

Pot. at e = 1·5 cells.
Pot. at E = 1 cell.

Difference of potential between e and E = 1·5 − 1 = ·5 cell, *i.e.*, the same that it was when false zero of 100 divs. in fig. 5 was noted.

Thus the difference of potential between e and E remains constant, and the application of the + pole of battery to bridge does not alter the deflection on G. Fig. 7 shows condition of things with − pole of battery applied to bridge. The battery now being reversed, the perpendiculars illustrating battery potentials are inverted, the + earth current potential, c, p, remaining of course the same as in the two former diagrams.

Pot. at e = ·5 cell.
Pot. at E = 1 cell.

Difference of potential between E and e = 1 − ·5 = ·5 cell. Thus the difference of potential between e and E is still constant, the deflection of 100 divs. on G remaining, therefore, undisturbed ; or—

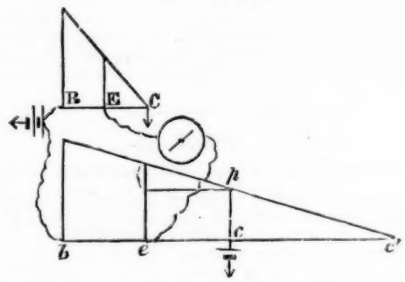
In fig. 5	...	...	...	·5 − 0 = ·5
In fig. 6	...	...	...	1·5 − 1 = ·5
In fig. 7	...	...	...	1 − ·5 = ·5

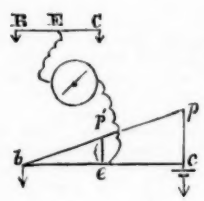
The learner must note that—

In fig. 5	...	e is ·5 cell + higher than E
In fig. 6	...	e is ·5 cell + higher than E
In fig. 7	...	e is ·5 cell − lower than E

The deflection of 100 divs. in the last mentioned case being, therefore, in the same direction as that in the two former.

FIG. 9.





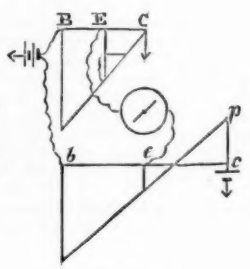


FIG. 8. FIG. 10.

In all three diagrams the proportion exists :— B, E : b, e :: E, C : e, c. In the present instance B, E = b, e, therefore E, C must = e, c, and any departure from this rule, whether considered geometrically or electrically, would clearly throw out the equality existing between the three differences of potential as shown under the above three conditions, whilst consequent on any variation in these differences of potential, the deflections due to the same would likewise vary. Hence it is clear that R (E, C) must remain constant in all three cases ; *ergo*, when a false zero is to be noted, that resistance must be unplugged at R which will, on the

subsequent application first of all of a + and then of a — battery current, produce in either case, a correct balance with cable.

Therefore for a theoretically correct C.R. test to false-zero, with an earth cnrrent of constant E.M.F. flowing into the cable, when false zero is being noted, previous to application of testing battery, R must be to x what m is to m'. When this is so, the bridge readings will be the same with both currents, and the further this rule is departed from the greater will be the difference between results Z to L and those C to L.

The truth of this will be rendered still more apparent to the learner on inspecting figs. 8, 9 and 10, which correspond exactly with figs. 5, 6 and 7 severally, with the exception that a ratio of 500 : 1,000 is employed instead of 1,000 : 1,000. So, in this case, to correctly balance x of 1,000, 500 must be unplugged at R, or $m : m' :: R : x$. Here 500 ohms (which is to x what m is to m') is unplugged at R for the correct observation of the false zero.

N.B.—In the above examples (figs. 5, 6 and 7 and in figs. 8, 9 and 10) the several differences of potential, as represented geometrically by the portions of perpendiculars marked with small brackets, are, in both series, by construction, *equal*.

Figs. 11, 12 and 13 show practical arrangements corresponding severally, firstly with figs. 5, 6 and 7, secondly with figs. 8, 9 and 10.

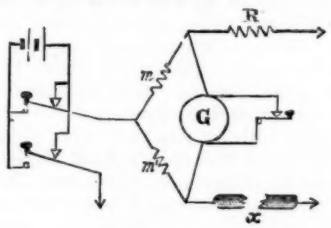


FIG. 11.

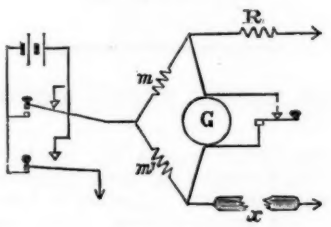


FIG. 12.

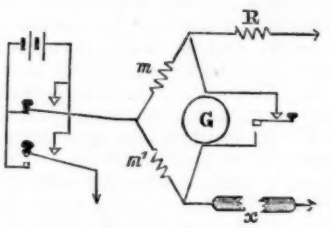


FIG. 13.

The following two C.R. tests (one taken immediately after the other) of a cable lately laid and in perfect condition, point at once to the great superiority over all others of the false-zero method for eliminating error due to earth current effects.

1.—*C.R. Bridge Tests to Scale-Zero:—*

Arrangement of apparatus as in fig. 3.
Testing battery, 20 Minottos, 23 ω per cell.
Bridge ratio, 100 : 1,000.
E.M.F. of earth current, 4 cells, odd, *negative*.
Mean result, Z to L (R') ... ... 1451·5 ω
Mean result, C to L (R'') ... ... 710·5 ω
x calculated from ordinary mean $\left(\frac{R' + R''}{2}\right)$ 10810 ω
x calculated from Dresing's geometrical mean ($\sqrt{R' R''}$) ... ... 10313 ω

2.—*C.R. Bridge Tests to False-Zero:—*

Arrangement of apparatus as in fig. 3.
Testing batteries, 20 Minottos, 23 ω per cell.
Bridge ratio, 100 : 1,000.
E.M.F. of earth current, 4 cells, odd (very constant).
Deflection to false-zero, 625 divisions of scale.
Value at R whilst false-zero noted, 1001 ω
G = 7015 ω
S = 80 ω
Mean result (to false-zero) Z to L (R') ... 1001 ω
Mean result (to false-zero) C to L (R'') ... 1001 ω
Then x = 10010 ohms.
Sensitiveness of shunted galvanometer between bridge terminals such that adding or subtracting 1 ohm at R varies deflection by 3 divisions of scale.
N.B.—Correct C.R. of cable when laid = 10011 ohms.

ELECTRIC LIGHTING IN THE UNITED STATES.

By CHARLES LEVER.

(*Continued from page* 310.)

THE system of arc lighting devised by Mr. Sperry, of Chicago, is well known, and is extensively employed in that city. The lamp is of the differential clutch type, and works with a short arc and a heavy current. In appearance the dynamo is similar to the new Weston machine. Only single carbon lamps are used in the Sperry system, and the design of the lamp is peculiar, as the triangular frame which supports the lower part of the lamp holding the lower carbon and globe is very close to the carbons ; in fact, so much so, that it must be very awkward to trim the lamp.

Some of the installations on the Sperry system in Chicago burn day and night. A switch is provided on each side of the case containing the regulator to cut out the lamp, so as to enable new carbons to be put in while the other lamps in the series are burning. From all accounts, this company is introducing a double lamp, which will no doubt be in operation shortly.

The Sperry Company certainly deserves some praise for its enterprise, as this system is rapidly gaining ground westward. At Omaha (Nebraska), for example, the Sperry Company has started a supply station in opposition to the United States Company, and already a good number of lights are in operation in the different stores, &c. The opinion as to the two lights seems to be divided. The Paxton Hotel has adopted the Weston arc lights, whilst the Railroad Depôt is lighted by Sperry lamps. One would imagine that the competition is rather keen between these two short arc systems in Omaha, for the companies only charge $10 —say £2—per month for each arc light. Here and there a Thomson-Houston lamp is to be seen suspended on a wire stretched across the street, while the conducting wires hang in unsightly festoons from the nearest electric light pole ; but this lamp does not appear to make much headway in this city. At one of the principal restaurants is an installation of ninety Weston incandescent lights. The power is supplied by a vertical steam engine in the cellar, which drives a Weston shunt-wound dynamo. All the lamps in the bar and supper rooms are provided with switches, so that they can be put in or out, the shunt-wound machine being perfectly self-regulating.

Satisfied with the success achieved at Omaha, the Sperry Company has started a lighting station still further west at North Platte (Nebraska). The dining room of Railroad Hotel is lighted on this system, while twenty or thirty Sperry lights are also used in the principal stores and saloons. A large wooden shed has been erected close to the railroad depôt for the boiler, engine and dynamo, and one or two lights illuminate the exterior, probably to show the inhabitants of this rising little town where they can get the electric lights.

Cheyenne (Wyoming), the next important town westward, is rather remarkable on account of the

electric light having been introduced there before gas. For some time past the residences of a number of wealthy cattle-men have been illuminated by incandescent lights, although it is only quite recently that a gas company has been started. There is also a supply station at Cheyenne on the Brush system, the arc lights being used in the numerous stores, saloons, &c., and also in the railroad restaurant.

The city of Denver (Colorado) has a supply station on the Brush system, 300 single carbon lamps being used in the different hotels and stores. The Windsor Hotel has adopted Brush lights in the main entrance hall, but the dining room is lighted by three large Siemens gas lamps, which vitiate the atmosphere very much. The outskirts of the city are lighted by four towers about 100 ft. high, each containing three powerful Brush lamps. These towers are constructed of iron tubing, and are triangular in shape, gradually narrowing from the base upwards. A large horizontal steam engine drives the dynamos which work all the lights in the city and those on the tower system, and it speaks well for the management that the lights have not failed once during the past three years, although this engine is the only one in the supply station. There is no public lighting in Denver, but the lights which are already in use appear to burn very satisfactorily. It is a pity that the proprietors of the magnificent Tabor Grand Opera House do not adopt the incandescent system, for a new and beautiful theatre like this one ought to be lighted electrically.

To see Brush lamps working at their best, one must go to Salt Lake City (Utah), where the Rocky Mountain Electric Light Co. supplies 140 Brush arc lights, which, under the management of the company's electrician, Mr. Tupper, work exceedingly well. This company charges $15, say £3, per month for each light. A substantial brick building contains the boilers, engines, dynamos, and all other necessary apparatus for this supply station. A horizontal engine of 100 indicated H.P., does the greatest part of the work, but there is also a Westinghouse high speed engine which drives a forty lighter, and which works very nicely. The lights are used in the Walker House, the Continental and other hotels, and in the principal stores and saloons; but there is no street lighting. Mr. Tupper evidently does not attach much importance to the Brush automatic regulator, for he regulates the current by hand, and he is a man who believes in looking after everything himself. Whether the good working of the lamps is due to the hand regulation of the current, or to the good adjustment of the lamps themselves, it would be difficult to say, but nevertheless it is astonishing to see the lamps burn so steadily and quietly in comparison with those of other places. At the Walker House is a new type of Brush lamp, designed by Mr. Tupper, which is exceedingly neat, and might with advantage be adopted by the Brush Co. One of our English electricians, Mr. Pope Cox, is also busily engaged in installing a number of incandescent lamps in Provo, near Salt Lake City, under the auspices of the Rocky Mountain Co. It is to be hoped that Mr. Pope Cox may soon be engaged in installing incandescent lamps in the Salt Lake Theatre, as this building would be much improved in ventilation if electric lights were used in place of gas.

In Ogden City, two hours run from Salt Lake City, is another Brush supply station, though by no means as important as the one just described. Here the lights are principally used in the streets, the lamps being fixed on the ordinary wooden electric light poles.

After leaving Ogden, there is nothing of importance to the electrician until he arrives at San Francisco. In this city, only Brush lamps are to be seen. There is no public electric lighting, but from 300 to 400 Brush lamps are supplied to the principal hotels, theatres, stores, &c. The type of lamp used in San Francisco for exterior illumination, is different to the ordinary Brush type. The frame is triangular, and is by no means ornamental. In front of the block adjoining the Baldwin Hotel in Market Street, is a row of some fourteen of these arc lights placed quite close together, so that this part of the street presents a very brilliant and gay appearance at night. The beautiful dining-room of the Palace Hotel is disfigured to some extent by the careless manner in which the wires are run to the arc lamps. It is really a pity that a little more pains had not been taken in keeping these wires out of sight as much as possible, or at any rate in putting them up neatly. In the magnificent courtyard of the same hotel, is an excellent specimen of the space which two arc lamps will effectually illuminate. This courtyard, which is seven stories high, was formerly lighted by several hundred gas burners, yet the two Brush arc lamps light the place very well. All the pillars and railings around the verandahs being white, assist in reflecting the light. The theatres are all lighted in the interior by gas, and, in fact, for the population, electric lighting has not progressed as much in San Francisco as in some other cities. At one time, the California Electrical Co., whose works are in Market Street, attempted electric lighting, but did not find it profitable.

The City of San José, about forty miles from San Francisco, is lighted entirely by Brush lamps on the tower system. In the outskirts of the town four towers are placed, each constructed of two large wooden poles spliced together like an ordinary mast, with three large Brush lamps at the top. Sometimes these are called mast lights. Each mast is about 100 feet to 120 feet high. In the centre of the town is a very peculiar tower made of iron tubing, although the appearance is rather neat. It is quadrangular in shape, and gradually tapers from the base to a height of about 120 feet. The four largest tubes, forming the corners of the tower, are sunk in the ground at opposite sides of the street, two on one side and two on the other side. An arch constructed of light iron trellis work binds these tubes together, and the vehicles in the street drive through this archway. The tubes are also suitable trellissed up to the top, so as to give the requisite strength to the tower.

(*To be continued.*)

THE DAVEY PRIME MOTOR.

THE question of small motors from one-half to five or six horse-power is not by any means decided or settled, although we have already a number of hot air motors, gas engines and water motors, which are designed especially to meet this want. Most of these engines are too complicated to come into general use, and there is much difficulty in keeping the piston and cylinder of hot air motors and gas engines in good order, the heat in these parts being so intense that it burns up the lubricating oil too quickly. The principal requirements for the practical usefulness of such small motors are simplicity in construction and attendance, and durability, without risk of explosion. Although there are many steam engines designed for this purpose, they hardly satisfy the purchaser, on account of having too small boilers, which renders safety uncertain, besides which, the parts are too complicated, rendering skilled attendance absolutely necessary.

The engraving shows a novel construction in a machine invented by Mr. Henry Davey, of Leeds. It is a low pressure condensing engine. The pressure in the boiler never rises above atmospheric pressure, and the boiler is, therefore, as non-explosive as a tea kettle. Hence, we at once do away with all the dangers and difficulties which are experienced with the ordinary steam boiler. The only function of the steam is to create, by condensation, a vacuum, which is the motive power. The cylinder, unlike that of other engines, does not require any oiling or lubrication, being made of bronze, with bronze piston head and rod. Unlike the ordinary boiler and engine, in which the water level in the boiler is a matter of vital importance, and any failure of the water supply fraught with more or less danger, the water level of the Davey engine is constant and unvarying, and the quantity of water actually

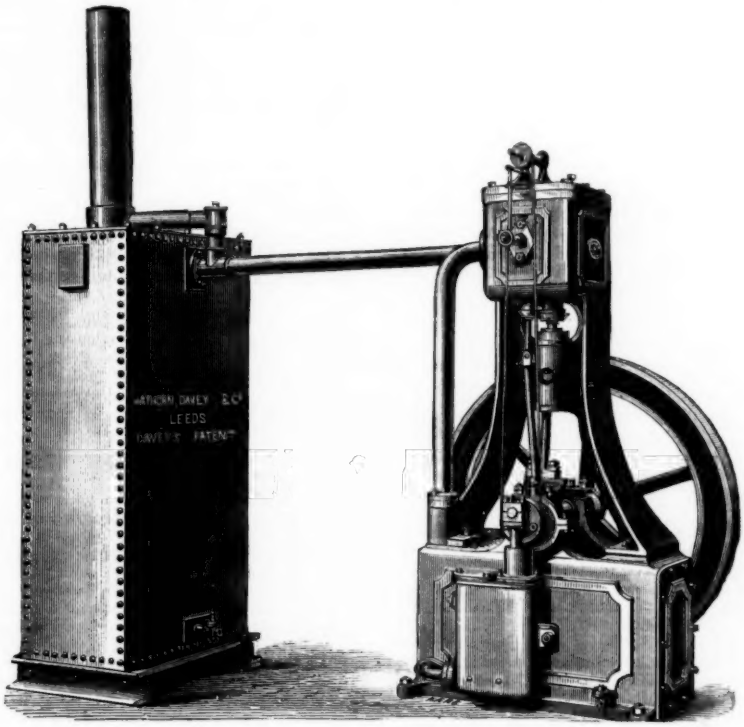
consumed so small as to remove all difficulty of keeping up a supply.

The boiler on the left of the illustration is arranged in the form of a hopper, so that coke sufficient to last for eight hours can be put in at one time, and the machine requires no further attention till the expiration of the eight hours. Two of these hopper boilers and engines have been running at the Inventions Exhibition from eight o'clock in the morning till ten o'clock at night continuously, driving dynamos for electric lighting parts of the building, and they have been awarded a gold medal by the jury, as well as a special gold medal by the Society of Arts.

At the Royal Agricultural Show at Preston, careful experiments were made to ascertain the consumption of fuel, and it was found that six pounds of gas coke were consumed per effective horse-power per hour. The only prize medal that was awarded for engines at this show was awarded to the Davy engine.

The motor solves the question of private installations of electric lighting. There being no safety valve, no exhaust, no steam gauge, no gauge cocks, no boiler feed pump or injector, nor any of the ordinary adjuncts of a steam engine, the Davy engine can be perfectly managed by an unskilled man, and as his services are only required three or four times a day the engine requires a minimum of attention.

Messrs. Hathorn, Davey and Co. have completed several installations of the electric light by means of their motor with perfect success, the light being steady and unvarying.



THE EFFICIENCY AND DURATION OF INCANDESCENT LAMPS.

(*Concluded from page* 316.)

TEST FOR DURATION.

FOR the duration test proper the three rooms of the Brush exhibit during the exhibition were utilised. The lamps were placed in boxes arranged in a circle in the middle room, which was securely boarded up, with the exception of one door opening into the watchman's room. This door was securely locked and sealed, except when measurements or adjustments were being made. A glass pane set in it allowed of inspection of the lamps when the door was closed. On the opposite side of the duration test room was a shop in which all necessary electrical work was done. In a corner was the photometer room, containing the photometer used in the efficiency measurements. The exhibition building around the three rooms was well lighted by extra lamps in circuit, and the whole was under the inspection of a watchman. When the committee finished their daily work in the duration test room, the door was locked and sealed in the presence of one of the committee and remained closed until the next day, when the seal was examined before the room was opened. It was always found intact. While the room was closed, inspection of the lamps was made through the glass set in the door. These inspections were made every half hour, and whenever a lamp was observed to be out the time was recorded. The lamp was examined the next time the room was opened, and removed if found to be broken. It was feared that lamps might be accidentally broken, and provision was made in the code for replacing such lamps by others. In order to avoid breakage the lamps were never touched except to adjust their position in the socket, or to remove dust which had settled on them. Only one lamp (Stanley No. 12) was accidentally broken in the test, and this occurred while making a connection, by accidentally touching its leading wire to the binding post of the next lamp, giving the lamp 96 volts instead of the 44 required. When the room was open, no one not connected with the test was allowed to enter it unless accompanied by a member of the committee.

The lamps were arranged in a circle of one hundred inches radius, the centre of which was occupied by the slit of the Methuen burner. This distance was carefully measured and verified. The circle contained boxes for seventy-one lamps, each box being eight inches wide. The lamp sockets were screwed to brass nipples on the hundred-inch curve. Each box had a door which opened inward and downward. The back of the box was open, the escape of light in that direction being deadened by reflection on the blackened wall of the room, and still further prevented from affecting the photometer disc by curtains above and below the lamps. Each box contained an opening in its top of two inches wide and six inches in length, for the purpose of assisting in carrying off hot air. The doors and the partitions separating the boxes were made of sheet zinc. Each lamp circuit lay in a vertical plane. One of the lamp leads passed from the upper main down through a slot in the upper shelf into the box to the socket. The other passed through the opening in the lower part of the box down behind the pasteboard to a binding post on the lower shelf. These posts were placed on a strip of wood covered with several coats of shellac, and fastened by pins to the front edge of the shelf. This strip was kept wiped clean from dust or anything that might cause leakage over its surface. To the binding post was also connected one end of the adjustable German silver resistance, the other end being soldered to the lower main. The reels were of different sizes, the largest being about twelve inches square and two inches wide. Cotton insulated German silver wire was used, the size varying from 22 to 26, American gauge. The turns were loosely wound on the reel, and the air cooling was in all cases sufficient, no charring of the insulation or short circuiting of the wire occurring. Some of the lamps

required as much as three hundred feet of wire to procure adjustment of potential. The spare wire of each reel was wound on a spool fastened to the front side of the shellaced strip. The mains were supported by porcelain insulators, and after the leading wires had been soldered were wrapped with rubber tape. The inside of the room being lamp-blacked throughout, a slight leak was sometimes perceptible from the upper main to the ground, but the insulation resistance between the mains through the lamp sockets and between the upper main and the brass terminals was tried both before and after the test and found to be practically infinite, no deflection being perceptible with an E.M.F. and galvanometer, capable of indicating thirty megohms.

The duration test room was ventilated by large holes, cut both in the roof and in the floor. The temperature of the room averaged about 3° C. above that of the air in the building. The temperature of the boxes was frequently tested and found to be about 16° C. above the rest of the room, rising to 18° when the doors were closed. The highest temperature of the room during the test was 33·5° C.

Each box door contained a slot cut to the size of the carbon of the lamp in the box. This slot was covered by a movable shutter. It was found, however, that as a rule the reflection from the walls back of the boxes was inappreciable on the photometer and measurements were generally made with doors down, it being thought better that any extra light should be in favour of the lamp, than that risk should be run of cutting off any light by errors in size or shape of the slot or in displacement of the door due to the continual handling.

The general method of daily work was as follows: The forenoon was devoted to calibration of the potential galvanometer, to adjustments of potential of the lamps by means of the German silver resistances, and to the calculation and recording of the previous day's work. The photometric measurements were made in the afternoon. This was varied to suit circumstances. Three persons took part in each observation. The lamp was first put in circuit with the current galvanometer. This was done by disconnecting the lower leading wire of the lamp from the binding screw and connecting it to one of the leads of the current galvanometer by a connector, to which was also fastened one of the potential leads, the other being on the upper main. The return lead from the current galvanometer was clamped to the binding post on the shellaced strip. The tangent galvanometer and its leads were thus in circuit with the lamp, but as the resistance of both was less than a tenth of an ohm, the increased resistance of the circuit was not more than $\frac{1}{100}$ of the lowest resistance lamp tested. After the connections were completed ten photometric measurements were made and the mean taken as the candle-power. Two observers read the galvanometers, a double reading of the potential galvanometer being made with the currents in the tangent in each direction. As soon as the electrical measurements were finished a signal was made and the connections were shifted to the next lamp. Each observation was, therefore, the average of ten photometric, four potential and two current readings. The observations were first made with the potential under control of the automatic regulator, but it was soon found necessary to depend on hand regulation during measurements.

A series of calibrations of the potential galvanometer had been made before the test for duration commenced. A resistance of 100,000 ohms was used in this test in the galvanometer circuit for all potentials of seventy volts or less, and 150,000 for higher potentials. The preliminary series gave a constant of 3·615 for 100,000 and 5·436 for 150,000 at the mean temperature of the room.

The observations were calculated so far as was possible at the time of observation, each observer making his own calculation. As the average time of observation on each lamp was three minutes, this work was very much hurried. Tabulated forms were generally used. The whole of the day's work was gone over again from the original records in the evening and the next morning, and results were finally reviewed by another computer after the test was finished.

In reviewing the results of the test, the committee note discrepancies in the candle-power. From the continuous nature of the test, no repetition of the work was possible, and the discrepancies referred to were shown to be such, only by observations on subsequent days. Under these circumstances no verification could be made. In order to facilitate comparison they feel justified in rejecting the observations of April 25, 27, 28, 29* and May 15 and 25,† as not in accord with the other of the series.

The committee present the following summary of the results (see tables):—Whenever the candle-power was observed at too high or too low potential, the former is reduced to what it would have been at normal potential by such an allowance as seems proper, the general rules being given for each lot of lamps. These values are derived from the data given in the tables of efficiency and duration, and are believed to be substantially correct.

* Marked magnetic disturbances were reported from the magnetic observatories at Toronto and at Los Angeles, Cal., between April 25th and 29th.

† Through the courtesy of Prof. Hilgard, Supt. of the U. S. Coast and Geodetic Survey, the committee have since the termination of the test received a complete set of tracings recorded by the bifilar magnetometer at the Magnetic Observatory at Los Angeles, Cal. These tracings show marked variations of H. on April 26th, 27th, 28th, and May 25th, which might partially account for the discrepancies on those days.

EDISON.

In allowing for the potential being other than normal, one volt is assumed to cause a difference of mean horizontal intensity of one candle. The whole lot of lamps behaved with great uniformity, there being in all a gradual increase of resistance throughout the test.

STANLEY-THOMPSON.

The same allowance is made for candle-power per volt with 96-volt lamps as with the Edison. In correcting the 44-volt lamps, an allowance of one-and-a-half spherical candles is made for one volt. The test of the latter was not perfectly satisfactory, as most of the lamps were connected two in series. The only adjustment of potential possible was the sum of the potentials of the two lamps, and as soon as the resistance of the lamps began to change, one of each pair was at a higher potential than normal, the other lower. As soon as possible the lamps were placed in separate circuits. The average potential of each lamp during its life, taken from the daily observations of potential, is given in the table to assist in interpreting the results. Number 3 lamp in particular was tested at so high a potential that it was thought best to introduce another, and number 12, which had never been measured for efficiency, was tested for life, but was accidentally destroyed after 307 hours.

WOODHOUSE AND RAWSON.

The allowance for these lamps is one-and-a-half spherical candle per volt, that being about the average of ten lamps tested at two different potentials. Most of the first lot tested were connected two in series, and the same objection holds here as with the Stanley-Thompson lamps. The committee were very willing, therefore, to test a second lot of lamps, which were placed in separate circuits from the start. The resistance of this second lot gradually decreased for three days, the candle-power rising, and then falling as the resistance increased. All the lamps were much discoloured.

WHITE.

This set of lamps changed greatly in their candle-power. Every lamp decreasing in resistance, the average decrease being two-and-a-half ohms in about 100 hours, the candle-power increasing greatly. The resistance then began to increase and the candle-power to fall off, but after 250 hours the candle-power was still higher than in the preliminary efficiency test. In correcting, the allowance of one-and-a-half spherical candles per volt is made.

WESTON (110½ VOLT).

The action of these lamps is shown by the tables of daily observations. As predicted by Mr. Weston, they increased rapidly in resistance at first, the candle-power falling greatly. The correction of one spherical candle per volt is assumed in correcting these lamps.

WESTON (70 VOLT).

A difficulty was experienced with all the Weston lamps in getting the point of 0° lat. 0° long. exactly towards the photometer. Owing to the peculiar oblique position of the major axis of the curve of horizontal illumination, in relation to the plane of the carbon shanks, a slight rotation of the lamp in its socket materially affected the photometer reading. The fall of candle-power in number 62 may have been partially due to this, as the attempt was made on May 5th to adjust it. The increase of resistance, however, shows a deterioration in the lamp as well. The resistance of these lamps as a whole remained about constant, the changes being but slight in either direction. The correction allowed is one and three-tenths spherical candle per volt, determined by measurements of a lamp at different potentials.

EDISON LAMPS.

Lamp.	Hours of test.	Life of lamp.	Candles. Efficiency measurements.		Candles.		
			Spher.	Horiz.	Spher.	Horiz.	
1	1,066	survived	15·3	18·8	9·3	11·4	After 1,006 hours.
2	1,065	,,	13·6	16·7	9·9	12·2	,, ,, ,,
3	,,	,,	14·2	17·2	9·7	11·7	,, ,,
4	,,	,,	15·0	18·6	9·6	11·9	,, ,, ,,
5	,,	,,	15·7	19·5	10·5	13·0	,, ,, ,,
6	,,	,,	14·0	17·1	10·3	12·7	,, ,, ,,
7	,,	,,	14·0	17·6	9·3	11·7	,, ,, ,,
8	,,	,,	16·0	19·4	10·1	12·2	,, ,, ,,
9	,,	,,	14·4	17·7	9·7	11·9	,, ,, ,,
10	,,	,,	14·0	17·7	9·8	12·4	,, ,, ,,
11	,,	,,	16·1	20·3	9·8	12·4	,, ,, ,,
12	,,	,,	13·1	16·7	10·3	13·1	,, ,, ,,
13	,,	,,	14·9	18·3	10·1	12·4	,, ,, ,,
14	,,	,,	15·1	19·0	9·3	11·7	,, ,, ,,
15	,,	295	15·1	19·0	12·4	15·6	,, 260 ,,
16	,,	survived	15·5	19·6	9·3	11·7	,, 1,006 ,,
17	,,	,,	16·0	20·3	8·9	11·3	,, ,, ,,
18	,,	,,	15·0	18·5	9·0	11·1	,, ,, ,,
19	,,	,,	15·4	18·8	9·5	11·6	,, ,, ,,
20	,,	,,	15·2	18·9	9·0	11·2	,, ,, ,,

STANLEY-THOMPSON LAMPS, 96 VOLTS.

Lamp.	Hours of test.	Life of lamp.	Candles in efficiency tests.		Candles.		
			Spher.	Horiz.	Spher.	Horiz.	
26	1,065	78	12·8	15·4	12·3	14·7	After 53 hours.
28	,,	233	16·7	19·3	9·2	11·0	,, 218 ,,
29	,,	176	16·2	19·1	10·1	11·3	,, 172 ,,
30	,,	survived	12·7	15·4	6·2	7·5	,, 1,000 ,,
33	,,	257	14·0	16·8	8·3	9·8	,, 241 ,,
34	,,	525	13·9	16·6	8·5	10·2	,, 502 ,,
35	,,	100	13·2	16·2	10·4	12·7	,, 100 ,,
36	,,	301	16·3	19·4	8·4	10·0	,, 241 ,,
37	,,	882	13·4	16·1	6·5	7·8	,, 837 ,,
41	,,	683	11·9	14·3	7·9	9·5	,, 670 ,,

STANLEY-THOMPSON LAMPS, 44 VOLTS.

Lamp.	Hours of test.	Life of lamp.	Average potential.	Candles in efficiency tests.		Candles.		
				Spher.	Horiz.	Spher.	Horiz.	
								Hours.
1	1,065	309	43·60	11·8	14·6	6·6	7·8	After 290
2	,,	143	44·40	10·4	12·5	10·2	12·3	,, 101
3	,,	137	46·85	16·0	19·7	8·0	9·8	,, 101
4	,,	178	43·95	14·2	17·6	9·0	11·2	,, 173
6	,,	288	43·85	10·4	17·1	6·8	8·3	,, 280
7	,,	303	42·40	12·6	15·4	9·5	11·6	,, 283
8	1,047	survived	43·65	10·8	13·2	5·4	6·6	,, 987
9	1,065	40	...	16·6	19·9			
10	,,	206	43·20	16·3	19·7	10·0	12·1	,, 202
11	,,	275	44·10	15·3	19·4	6·5	8·3	,, 265
12	865	307*	...	11·0†	...	9·2	...	,, 307

* Accidentally destroyed. † Standard reading. No reduction factor.

WOODHOUSE AND RAWSON LAMPS.

Lamp.	Hours of test.	Life of lamp.	Average potential.	Candles in efficiency tests.		Candles.		
				Spher.	Horiz.	Spher.	Horiz.	
								Hours.
1	1,065	41	...	18·5	21·5			
3	1,065	214	55·60	19·7	24·0	13·0	15·9	After 213
4	1,065	203	54·90	17·8	21·0	12·3	14·5	,, 170
5	1,065	440	54·55	13·3	15·6	10·4	12·2	,, 289
6	1,065	395	54·15	12·7	14·4	10·9	12·3	,, 289
7	1,065	423	55·80	14·2	17·7	10·1	12·6	,, 289
8	1,065	118	55·75	13·6	16·5	12·8	15·5	,, 78
9	1,065	716	55·00	17·0	20·4	6·6	7·8	,, 716
10	1,065	69	55·20	10·8	12·7	12·4	14·6	,, 32
18B	1,065	278	55·15	14·0	16·9	13·3	16·1	,, 266
30	332	survived	...	18·5	22·7	14·8	18·3	,, 273
31	332	227	...	17·2	20·9	14·5	17·5	,, 200
32	332	survived	...	17·4	21·3	13·9	17·1	,, 272
33	331	,,	...	19·0	22·7	14·6	17·4	,, 272
34	331	235	...	16·9	20·8	16·5	20·3	,, 200
35	331	272	...	19·6	23·5	13·5	16·2	,, 272
36	331	survived	...	21·4	26·0	12·4	15·0	,, 272
37	331	177	...	18·7	22·9	17·6	21·5	,, 151
38	331	224	...	17·9	20·8	17·0	19·7	,, 200
00	331	213	...	...	20·0*	15·3*	...	,, 198

* Standard reading. No reduction factor.

WHITE LAMPS.

Lamp.	Hours of test.	Life of lamp.	Candles in efficiency tests.		Candles.		
			Spher.	Horiz.	Spher.	Horiz.	
1	312	survived	10·8	13·1	15·9	19·2	After 253 hrs.
2	312	,,	11·0	13·2	14·3	17·2	,, 252 ,,
3	312	,,	9·1	11·1	12·1	14·8	,, 252 ,,
4	311	,,	14·2	17·2	14·6	17·7	,, 252 ,,
5	311	,,	14·3	17·1	12·1	14·4	,, 252 ,,
6	311	229	14·6	17·6	15·4	18·5	,, 227 ,,
7	311	160	14·0	17·0	15·7	19·0	,, 132 ,,
8	311	survived	11·7	14·2	13·2	16·1	,, 250 ,,
9	311	165	13·2	15·9	15·6	18·7	,, 132 ,,
10	310	survived	11·6	14·3	11·3	13·9	,, 250 ,,

WESTON LAMPS, 110½ VOLTS.

Lamp.	Hours of test.	Life of lamp.	Candles in efficiency tests.		Candles.		
			Spher.	Horiz.	Spher.	Horiz.	
1	1,065	227	16·6	18·4	10·8	11·9	After 198 hrs.
2	1,065	47	13·8	14·9	...	...	...
3	1,065	survived	13·4	14·8	7·1	7·8	After 1,006 hrs.
4	1,065	107	11·7	12·7	3·8	4·2	,, 77 ,,
5	1,065	320	15·0	16·4	10·4	11·4	,, 289 ,,
6	1,065	survived	10·4	11·2	10·0	10·8	,, 1,006 ,,
7	1,065	,,	17·3	19·0	2·9	3·2	,, 1,006 ,,
8	1,065	141	19·2	21·4	10·0	11·1	,, 141 ,,
9	1,065	survived	15·6	17·0	6·5	7·1	,, 1,006 ,,
10	1,065	823	18·2	19·7	10·0	10·9	,, 789 ,,
11	1,065	169	15·4	17·0	2·8	3·1	,, 148 ,,
12	1,065	81	21·3	23·3	13·9	15·3	,, 76 ,,
13	1,065	256	15·4	17·0	6·0	6·6	,, 241 ,,
14	1,065	213	18·3	20·4	2·6	2·9	,, 196 ,,
15	1,065	193	8·9	9·4	5·5	5·9	,, 193 ,,
16	1,065	survived	14·2	15·4	9·1	10·0	,, 1,006 ,,
17	1,065	41	11·3	13·1	...	...	...
18	1,065	survived	15·8	17·0	4·4	4·7	,, 1,006 ,,
19	1,065	65	19·4	21·9	10·7	12·1	,, 52 ,,
20	1,065	survived	18·5	19·9	9·5	10·2	,, 1,006 ,,

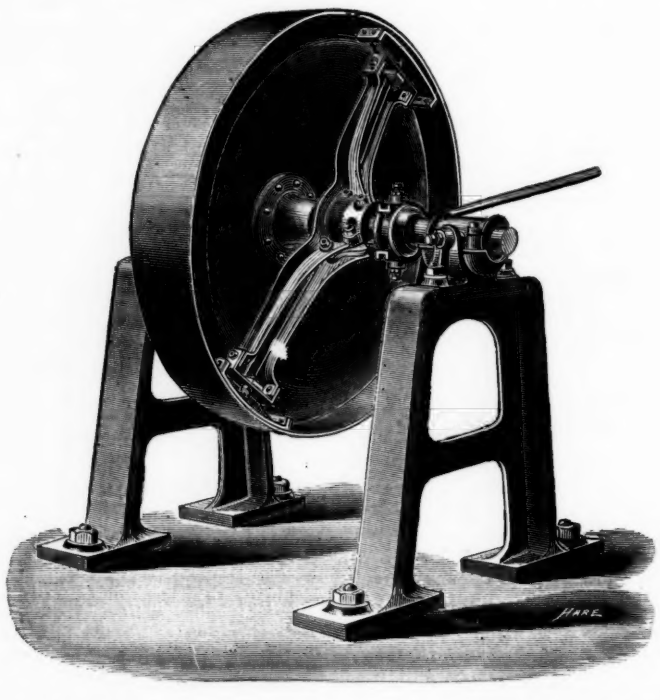
WESTON LAMPS, 70 VOLTS.

Lamp.	Hours of test.	Life of lamp.	Candles in efficiency tests.		Candles.		
			Spher.	Horiz.	Spher.	Horiz.	
51	524	260	14·3	16·0	7·7	8·6	After 249 hrs.
54	524	survived	14·0	15·2	13·1	14·4	,, 465 ,,
55	524	,,	16·7	18·3	14·8	16·3	,, 465 ,,
56	524	,,	14·7	16·4	13·9	15·7	,, 465 ,,
58	524	,,	16·3	17·9	13·3	14·6	,, 465 ,,
59	524	223	15·6	17·6	14·9	16·8	,, 176 ,,
61	524	survived	12·7	13·8	12·5	13·7	,, 464 ,,
62	524	,,	13·9	15·4	9·9	10·9	,, 464 ,,
63	523	,,	14·3	16·3	14·0	16·0	,, 463 ,,
64	523	463	14·8	16·1	14·0	15·4	,, 462 ,,

INTERNATIONAL INVENTIONS EXHIBITION.

WESTON'S PATENT FRICTION CLUTCH.—Amongst the miscellaneous exhibits at the Inventions Exhibition which are of interest to the electrical engineer, may be mentioned Weston's Patent Centrifugal Friction Clutch, shown by the British makers, Messrs. Watson, Laidlaw and Co., of Glasgow, at their stand in the West Gallery, and in the Electric Light Annexe. The advantages of a good friction driving apparatus appeal very strongly to the electrical engineer; as notwithstanding the undoubted improvements which have lately been made in high speed engines for direct driving, dynamos must still be driven by belts or ropes in the majority of installations—almost necessarily so in all large ones. It becomes, therefore, a great advantage to have a completely independent control over the stopping and starting of any particular machine, and indeed of all the machines in a large installation. For this purpose, fast and loose pulleys, whilst objectionable even in the case of small belts, are quite inadmissible in the case of very wide ones, and obviously impracticable where ropes are used. Hence the value of a friction apparatus by means of which a belt or rope may be stopped without shifting it, or stopping the shaft. The clutch now under notice, and one form of which we illustrate in the annexed figure, would appear to have advantages which should strongly commend it to electrical engineers and users of electrical power. Its two chief distinguishing features are, that the friction is derived from centrifugal force; and that it is applied—not necessarily, but in most cases—at the rim of the pulley or wheel. Advantage is thus taken of a force which in some forms of clutch is a source of trouble, and has to be counteracted by springs: whilst by applying the friction at the rim of the pulley, the greatest possible leverage is obtained; consequently, a very slight amount of friction is sufficient to transmit great power, and all trouble from excessive heating is avoided. The friction apparatus consists essentially of a pair of arms, bolted or otherwise secured to the shaft, and to which are attached, by simple flexible connections, another pair of arms, which terminates in broad friction shoes curved to a radius equal to that of the inside of the pulley rim. When the shaft is revolving, these friction arms tend to move radially outwards (the actual movement is, of course, very slight), and binding against the inside of the rim of the pulley to carry the latter round with them. When first started

slip takes place for an instant or two or longer, if it is desired, to get up the speed of the machine that is being driven, very slowly—the length of time during which the full speed is to be got up can be easily regulated. The tendency of the friction arms thus to drive the pulley when the shaft is revolving, is restrained when the pulley is to stand, by simply pushing home two wedges on the end of a common sleeve, which slides a short distance on the shaft. These wedges hold the friction arms clear from the rim as long as it is desired to keep the pulley at rest. When the pulley is to be started, the wedges are simply withdrawn when the friction is applied, and the pulley got up to full speed automatically. A plain hand lever, without screws or gearing of any kind, suffices to work the wedges. In the illustration, the friction arms are shown applied to an improved form of disc pulley, now being made by Messrs. Watson, Laidlaw & Co. In this pulley, the discs are of mild steel; but, instead of being flat, they are dished by special machinery, thereby imparting to them great stiffness, whilst retaining the important quality of lightness. The entire absence of arms from this pulley, would appear a great recommendation, alike on the ground of safety and economy of power. The friction apparatus is equally applicable to rope pulleys, geared wheels, or as a disconnecting coupling. We understand that large numbers of the apparatus have been made during the last few years, both by the British makers and in America, for the driving of high speed machinery, especially the centrifugals of sugar works and hydro-extractors. The apparatus is also largely used in the United States for the driving of dynamos; but has only been lately offered by the makers here for this purpose. A friction pulley, however, similar to the one shown in our illustration, 6-feet 3-inches in diameter, is at work nightly in the Electric Light Annexe at the Exhibition, transmitting over 60 H.P. It drives a Siemens machine, lighting the incandescent lamps of the Middle Court, opposite the principal entrance. The makers also show a number of the clutches at their exhibit in the West Gallery—for which, it may be incidentally mentioned, they have been awarded a gold medal—whilst we understand that, amongst others, the Anglo-American Brush Electric Light Corporation has lately applied the apparatus at its installation at the South Foreland; Muir & Mavor, at their installation in connection with the Post Office at Glasgow; Anderson and Munro, at the Caledonian Railway Station, Glasgow; and Brückner, Ross, & Consorten, at Vienna.



AN ELECTRO-MECHANICAL CLOCK.

AN invention has been introduced into this country from America, entitled the Electro-Mechanical Clock, in which, while the mechanism remains similar—with some modifications—to that in an ordinary time-piece, the necessity of winding, regulating, &c., by hand, is avoided. The inventor found that purely electrical clocks, where the entire motive power was derived from the electric current, were subject to serious drawbacks, among others from the immense number of contact breaks, or reversals of current, usually required in these arrangements, causing stoppages and irregularities in action of the movements. Again, in the ordinary mechanical movements in common use, he found the action was only maintained in a continuous manner by the power conserved in springs, or by falling weights requiring to be wound up by hand at frequent intervals, and thus storing up excessive power and producing great friction on the machinery.

Heavy springs or weights compel the usage of cumbrous gearing and strong pivots and bearings, where the storage of power is for any length of time. The tension of springs is an irregular quantity, from that of a newly-wound clock, to such time as winding must be repeated. The variations in the tension cause ever changing strains on the different portions of the mechanism, tending to incorrectness of time-keeping, and necessitating frequent repairs.

The electro-mechanical clock overcomes this difficulty by automatically winding itself once every hour, and giving to the spring only sufficient tension to run the clock during that period; securing nearly constant tension from hour to hour and year to year.

This is accomplished by an ingenious application of electricity, with a minimum expenditure of power, the current from one Leclanché or other battery cell giving all the needful energy, enabling the inventor to discard the powerful springs and cumbrous gearing ordinarily required, reducing the friction by some 80 or 90 per cent., and thus, it is claimed, producing a better, more correct, more durable and cheaper article than any other time recorder in the market.

The electro-mechanical clock requires a small spring, but little larger than the main spring of a watch, which is kept at a uniform tension, and acts directly on the hour wheel. This spring is wound in six seconds, and offers no interruption to the time while winding. It is kept only at a tension sufficient to run the clock one hour. It is then wound again by means of a small rotary electro-motor, which is connected with the mechanism in a manner that gives to the clock a most symmetrical appearance.

A common open circuit battery, used in telephones and electric bells, is concealed in the frame or case of the clock, and has sufficient power to wind the clock two years without attention. The hour wheel, each hour of its revolution, switches the electric current

through the motor, which rapidly revolves for six seconds, and communicates its rotary motion, by a gear wheel, to the barrel on the centre arbor containing the spring. This barrel (in one revolution) imparts sufficient tension to the spring to run the clock one hour; it stops the motor by breaking the electric current, and the battery rests for an hour, or until it is necessary to wind the clock again. This process is automatic and continuous from year to year, and the battery is used six seconds each hour, or less than 15 hours in a year, and is renewed in a few minutes at the cost of sixpence without interfering with the time of the clock.

We are enabled by the courtesy of Mr. B. F. Watkins, who is introducing the clock into this country, to give our readers some details connected with the construction and electrical arrangements pertaining thereto, and we have to thank him for the facilities he afforded us in showing the various parts and giving explanations, as well as for the open manner in which all our questions were answered and elucidated.

Beginning with the electrical fittings to the electro-mechanical clock as the more generally interesting part, we will explain, by means of the following diagrams, fig. 1 and fig. 2, the particulars relating to the self or automatic winding gear. Fig. 3 shows view of motor (switch details).

Explanation.—W, hour wheel; B, barrel connected by gearing with motor underneath; *b*, loose lever working on axle between hour wheel and barrel; *o* and *p*, pins on hour wheel and barrel and projecting inwards of sufficient length to engage lever as the wheels revolve; *c*, brass setting piece working on pivot *d*, and with spiral spring to keep a constant pull towards the wheels; *e*, a hard rubber or ivory piece to regulate the play of *c* and fastened to *f*, a flexible tongue connected with one pole of battery; *g*, steel spring giving the desired flexibility to above tongue; *h*, a hard rubber block to which *f*, *i* and *k* are screwed; *i*, contact piece to next clock; *k*, contact bar connected by frame to commutator of motor; *m*, *n*, pliable platinum-tipped contact springs; *t*, point of tongue *f*.

One pole of battery is joined to the free ends of wire coiled on the electro-magnets of the motor, the other pole being coupled to tongue, *f*. As the hour wheel completes one revolution in one hour, and the barrel turns on the same axle in the same time, the pin, *o*, on wheel must engage with the loose lever, *b*, and gradually lift it into contact with setting piece, *c*; the lever is long enough to push the setting piece off the step on the small ivory block, *e*, thereby causing the tongue, *f*, to fall, bringing the contact spring, *n*, into touch with the bar, *k*, on lower portion of supporting block, *h*; the angle to which the spring, *n*, is bent is made to ensure a good rubbing and firm connection. In this position the current from the battery passes through the frame of the clock and motor to the commutator of the latter, back to the other pole of the battery. The instant this circuit is complete the motor begins to work, the winding then proceeds, and as the barrel turns on its axle, the pin, *p*, must, in a similar manner to that on the hour-wheel, engage with the lever, which has just performed a portion of its duty in switching the current on to the motor. This lever has a further duty to carry out. The barrel being carried round during the winding at a rapid rate, the above pin, *p*, quickly takes it on till it presses and lifts the end, *t*, of the tongue, *f*, releasing the setting piece, which promptly returns by the tension of the small spiral attached to it to the position shown in the drawing. By this operation contact is made between the tongue, *f*, and point, *m*, of piece, *i*, from which runs a wire to the next clock if required. The current is thus switched off the motor (stopping further winding) and remains ready for use when wanted by another clock in the series, and properly set to undergo the same operation at end of the next hour. If a large number of clocks are in use in one building or block, they can all be controlled and regulated by one clock; the battery necessary to wind up one movement will suffice for a large number as well, a small current only being wanted for one clock; one clock only being wound at one time.

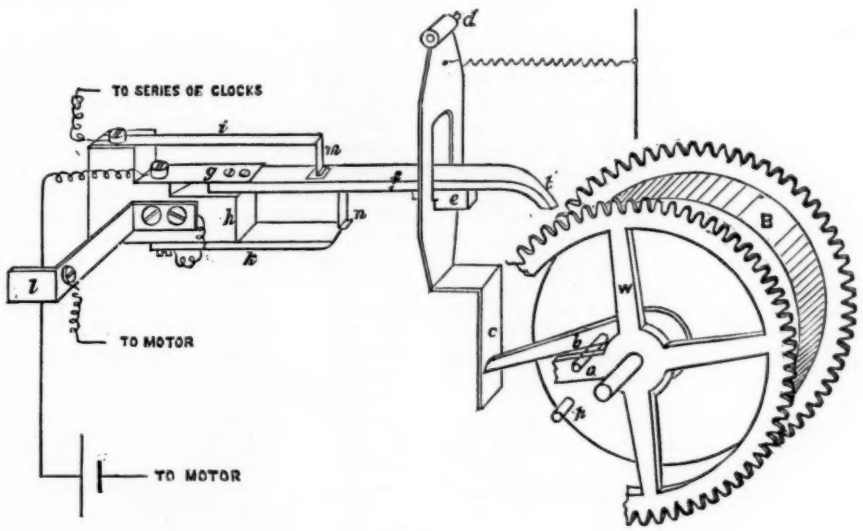


FIG. 1.

As the spring is placed in the barrel with a tension sufficient to run the clock one hour, several hundred could be wound in the space of an hour. Fig. 2 exemplifies a series of clocks at distances apart.

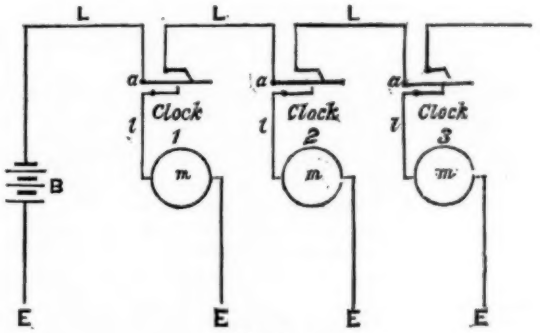


FIG. 2.

Explanation.—1, 2, 3 represent the series of clocks; *a* the switch, and *m* the motor of each separate clock; B battery; L and *l*, respectively, main and local line to E, earth.

As this diagram is drawn, it is demonstrating that clocks No. 1 and 2 have been already wound, and that No. 3 is in process of winding.

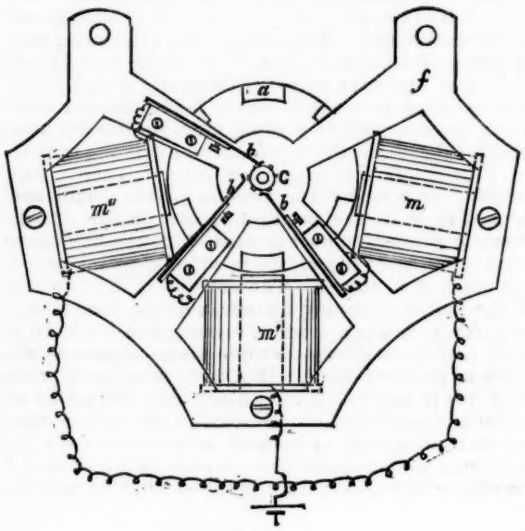


FIG. 3.

The electro-motor, it will be seen by the drawing, is complete in itself, consisting of a separate frame work, *f*, which is secured to the lower part of the clock plates, and conducts the current to the commutator, C, by way of the bearings on the armature, *a*, which is composed of six bars of iron set at equal distances apart, and fixed into the periphery of two brass discs. On the axle of this armature is placed a six-pointed commutator or contact maker; round this commutator are disposed three platinum spring brushes, *b*, in such a manner that one of them is always in contact with one of the points of the commutator while the other two spring brushes are free. These brushes are connected severally to one end of the magnet coils and in successive order: the figure defines this.

The electro-magnets are three in number. The free ends are joined together and connect to one pole of the battery. These magnets are placed round the armature, as shown, so that when one of the bars of the armature is opposite the poles of one electro-magnet, the brush joined to that magnet is free, while the next brush comes into contact and, exciting its belonging magnet, draws to it the nearest bar on the armature, which will always be the one preceding that last acted on. The magnets are so arranged that the armature can only revolve in one direction. Shunt coils, not visible in the figure, of fine wire, and corresponding in number with the points of contact, are provided to prevent the sparking at each break of contact by brushes.

The brushes consist of flat platinum springs set by small adjusting screws to the proper distances in relation to the commutator.

The above figures give all the electrical arrangements necessary for the ordinary working of one clock, or for a series of clocks, and the regulation will depend on the adjustment of the pendulum. The electro-mechanical clock possesses, however, the advantage derived from constant main spring tension and should, in consequence, keep better time than the usual time-piece.

The battery is fitted into the case with the clock; the cell supplied for the purpose is the ordinary Leclanché.

Should it be essential for the series of time-pieces to work in exact correspondence with each other, an arrangement has been provided whereby synchronism can be obtained every hour or once in 24 hours, as desired. This arrrangement consists of an electro-magnet with an easily attracted armature, constituting a relay, a frame carrying two levers, one straight and the second in form of a reaping hook having a projection at either end of the curve, pointing inwards. Engaged with the minute hand of the clock is a small disc, on each side of which is a saw-tooth whose cutting face points downwards. Fig. 4 will explain this better. There is also another small disc on the same axle working round once every hour and used for resetting the relay.

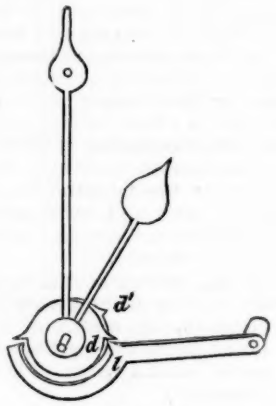


FIG. 4.

This figure shows the portion of the apparatus utilised in bringing the hands of dial to zero or correct time, and would seem to be an improvement on the common method of performing this action.

Supposing, for example, the circuit of clocks to be synchronised are at various stations along a railway line—in which case there would be a local battery at every station to wind its own clock—a separate wire for the purpose is not needed, as the telegraph line would be available, the time occupied in despatching the signal not interfering with the telegraphic service, and only amounting to a few seconds out of the 24 hours. At a given signal to each station along the line the clocks are switched into the main telegraphic circuit, the current is sent, passing through the above relay at each station, draws down its armature, thereby closing the local current through the motor, and also short circuits the magnet coils as soon as synchronism is accomplished, thus cutting out the clock from the service line and avoiding any chance of accident from prolonged action of the telegraphic current.

The motor then works, and begins winding, lifting the frame carrying the before-mentioned levers into a horizontal position, during which lifting the projections on the reaping hook lever, *l*, engage with the ratchet teeth on the small disc, *d*, fig. 4, bringing by this means the minute hand into the central position.

Five minutes fast or slow is the general amount of correction allowed for in the construction of the parts, but so much is not likely to be needed in practice. A larger margin of variation can be allowed for if required. Having accomplished the synchronising, the current is automatically cut off from the motor and things resume their normal state, with the one exception of resetting the relay; the second brass disc with one projection, *d'*, on its edge, as it gradually comes round during the next hour, at length releases the short circuiting bar, throws the coils of the relay back into the synchronising line, and thus restores the mechanism to its original condition.

It will be seen that the currents for sending the correct time down the line need be only sufficient to work the relay; the mechanical work performed by it is clearly at a minimum.

The good workmanship of the framework supporting the wheels, and the evident strength imparted to it by the rigid cast-iron back frame to which it is screwed, cannot escape notice. This latter frame obviates all danger to the works from possible shrinking or twisting of the case supporting them, and carries the pendulum without throwing a particle of weight on the actual movement.

The plates of the framework, in which the whole mechanical and electrical parts are supported, are stamped out of rolled brass in one operation, and are then in a finished state, no filing or other extra work being requisite, all edges being sharp and square, the pivot holes even are stamped out at the same time in perfect readiness for the reception of their respective pinions. Thus one process replaces the usual 20 operations or so, and produces a more perfect and exact plate, the repetitions of which are identical; 40 of these plates are stamped every minute at low cost for labour, and this alone should materially assist the manufacturers of the electro-mechanical clock in reducing the prime cost, and in competing with other makers.

In starting one of these automatic or self-winding clocks, it is customary to give a tension to the spring to maintain the action for an hour, besides the winding that will take place every hour, so that the power stored up in the main spring will always be enough to run the clock for the term of two hours. Every detail seems to be worked out with care, and there seems to be no reason why this ingenious mechanism should not come into extensive use.

MERRYWEATHER'S ELECTRIC HAND LAMP.

THIS lamp, as will be seen in the illustration, resembles in outward appearance an ordinary fireman's lamp. It consists of a battery and an incandescent lamp enclosed in a copper case, to which is attached a handle for convenience in carrying. An ebonite plate capable of vertical movement carries the carbon and zinc elements of the battery cells, the latter being six in number; when the light is not required, the elements are withdrawn from the exciting liquid and kept

in position by the pinching screws. The liquid employed is a special solution of bichromate of potash with sulphuric acid. Powerful parabolic reflectors are provided. The advantages claimed for the lamp are: (1) portability; (2) facility in charging; (3) capability of resting the battery when the light is not required; (4) safety for taking into inflammable gases when an ordinary lamp would be dangerous. The last-named recommends the lamp specially for use in mines, whilst firemen would find it of great service in entering houses full of gas.

NOTES.

The Electric Lighting Act.—At a meeting of the Executive Council of the Association of Municipal Corporations held at the Westminster Palace Hotel, Westminster, last week, a resolution was passed to represent to the Board of Trade the desirability of the promoters of undertakings under the Electric Lighting Act and the Tramways Act, giving security for the payment of all costs which might have been necessarily incurred by local authorities in protecting their own interests under those Acts.

Electric Lighting in Sweden. — The Thomson-Houston International Electric Company has received an order for electrical apparatus for lighting the entire city of Hermosand, Sweden. This contract is made directly with the city government, which will own and operate the plant. The city possesses a valuable water-power, which will be used for driving the dynamo machines. The Thomson-Houston International Electric Company states that its business is looking very favourable abroad, and that it is now negotiating with a number of large cities in Europe for several plants, ranging from 100 to 400 arc lights each.

Primary Battery Lighting.—The last issue of the New York *Electrical World* states that: "One evening last week a party of gentlemen met at the office of the Patent Battery Co., 51, State Street, to witness another test of incandescent lighting from a primary battery. During the exhibit five 16 candle-power lamps were alternately lighted and extinguished in rapid succession, and subjected to all manner of experimental tests. By means of a single lamp the time was easily and clearly distinguished on a watch held 150 feet distant, and at the distance of 90 feet a newspaper was read without any difficulty. Everybody present at the test was fully satisfied that the claims made by the inventors, Messrs. Kauffer and Goldner, were indeed modest when compared with results shown at the exhibit of incandescent lighting above referred to." What a test!

Portable Electric Lights. — Exchanges inform us that Messrs. Wilson and Gardner, of Boston, U.S.A., are perfecting a system of portable incandescent lighting by a primary battery which is claimed to be specially adapted for general domestic lighting, such as portable hand lamps and hand lanterns, also as library or stand lamps. It may be successfully used, it is said, for mining purposes and in side lights for vehicles, while it fills at the same time a long-felt want among bicycle and tricycle riders. The system is entirely different from the Trouvé, being, it is claimed, more simple, durable and economical.

The Electric Light in South Australia.—It has been determined to illuminate Rundle Street Arcade, Adelaide, South Australia, with the electric light. The installation will be imported from London, and arc lamps will be used. Should it be thought advisable to extend the principle to the shops, incandescent lights will be employed there. The arcade will therefore in all probability be the first building in Adelaide provided with the electric light.

The Telephone Litigation in America.—According to our contemporary and namesake in New York, the "friends" of Mr. Garland, the Attorney-General, have published a statement showing that the latter was not responsible for bringing the suit against the Bell Company in the name of the Government. A district attorney applied to the Department of Justice for authority to begin the suit, and the acting Attorney-General, in the absence of Mr. Garland, away for his vacation, gave permission. The "friends" referred to profess ignorance as to whether the Attorney-General possesses any interest in the Pan Electric Company, but say that from his well-known integrity they are unwilling to believe that there is the slightest impropriety in the action of the department.

The Drawbaugh Telephone.—The People's Telephone Company is about to renew the fight for existence. Its senior counsel, it is announced, will shortly make a motion before Judge Wallace for a new trial on the ground of newly-discovered evidence, consisting of the statements of several witnesses that they saw or heard the Drawbaugh telephones, or heard them described by many others, previous to 1874.

The National Telephone Company.—The *Financial News* understands that the demand for the new shares of the National Telephone Company is not very brisk, and remarks:—"Nor is this surprising, seeing the rapid and large increase in the capital of the concern. The present total, including debentures, amounts to £825,000, a pretty tidy sum when compared with the figures of other companies. We should certainly not advise investors to put their money into National Telephone shares, and we certainly should advise that company to be a little more moderate in its demands upon the public."

Maliciously Damaging Telephone Wires. — The National Telephone Company is offering a reward in the Whitehaven district for the discovery of the persons who have several times cut the lines between Workington and Whitehaven.

A Useless Telephone.—A wine merchant at Chicago rented a telephone which he claimed he could not operate to any advantage. He therefore had the instrument removed, and refused to pay for its use. The telephone company brought suit against him to recover $60, and got judgment for the amount. The case was then appealed, and the verdict obtained in the lower court was reversed.

Long Distance Telephony.—At the Telephone Convention in America the other day, Mr. A. S. Hibberd, of Wisconsin, said:—"The limit of distance in practical and profitable working is about 100 miles, although a considerable business is done over 150 to 200 miles of wire." Among the long lines in daily use in America are one from Milwaukee to Oshkosh, 110 miles; one from Detroit to Saginaw, 100 miles; and one from Buffalo to Rochester, 85 miles.

Telephone and Telegraph Poles.—The *Detroit Free Press* predicts and prays that in another year a telegraph or telephone pole will be as hard to find in that city as the North Pole. Could the facetious journal have its way, it would soon find that Detroit might as well be *at* the North Pole, for it would assuredly "get left," a most undesirable position to the American mind.

The Telephone at Dudley.—Last Saturday night at a monthly meeting of the South Staffordshire Mill and Forge Managers' Association, held at Dudley, Mr. Arthur Edgar Cotterell (Birmingham) read a paper on "The Development of Telephony."

It is mentioned that the National Telephone Company is about to open an exchange in Dudley.

Telegraph Revenue.—The receipts on the telegraph service from April 1st to October 10th, 1885, amounted to £935,000, against £925,000 for one day more last year.

Mr. Pender and the Western Union.—A telegram from New York announces that the resignation of Mr. John Pender, M.P., as a director of the Western Union Telegraph Company, has been accepted.

The *Financial News* ascribes Mr. Pender's resignation to the recent dispute between Mr. Pender, Mr. Cyrus Field and Mr. Garrett, and remarks, "There is trouble brewing in the camp of the Gould telegraph magnates, and the public had better stand from under."

Porterage of Telegrams.—A complaint is now made of the high charge made for porterage of telegrams where the addressee resides more than a mile from the receiving office. A correspondent, living just over three miles from a telegraph office, has to pay 3s. for each message delivered, and objects to paying so large a sum for the afternoon stroll of a boy who would not earn a shilling a day in any other capacity.

Intercolonial Telegrams.—The Postmaster General of Victoria has been endeavouring to secure a reduction in the rates charged for cable messages to and from New Zealand. A reply has been received to the effect that the New Zealand Government is ready to comply with the request, providing that the Government of Victoria will contribute a share of the cable subsidy. To this proposal the Victorian Government has replied, expressing willingness to furnish a quota of the subsidy if New Zealand will do likewise with regard to the Tasmanian cable.

Telegraph Contracts.—The Controller of Stores invites tenders for the supply of 3,423 red fir telegraph poles, to be delivered in London; from 3,404 to 5,027 to be delivered at Northumberland Dock (River Tyne) or West Hartlepool; and 1,623 to be delivered at Perth. Tenders for creosoting these poles are also invited. Tenders should be sent before noon on November 5th next, to Telegraph Street, London, E.C.

The Director-General of Stores for India is prepared to receive tenders to supply component parts of iron standard telegraph posts. The conditions of contract may be obtained on application to the Director-General of Stores, India Office, Westminster, S.W., and tenders are to be left at his office before 2 p.m. on 20th instant.

The Secretary to the Office of Works is advertising for tenders for the erection of a new post office at Windsor, and information may be obtained on applying at 12, Whitehall Place.

The American Telegraphists in Siam.—In consequence of the reports of the correspondent of the *Telegrapher's Advocate*, with the American telegraphists who recently, upon glowing promises, went to Siam, the journal named has laid the matter before the President of the United States, with the request that if, upon investigation, misrepresentation is seen to have been made, the safe and immediate return of the operators be demanded of the Siamese Government.

The Telegraph at Bokhara. — The telegraph office recently opened at Bokhara is, we learn, greatly appreciated by traders.

The Stearns Duplex.—Judge Wallace has refused the injunction asked for by the Western Union Telegraph Company against the Baltimore and Ohio Company, to prevent the latter from using the Stearns duplex.

The New West African Cable.—We read in the daily press that the *Silvertown* left Greenhithe on Saturday afternoon for St. Thiago, in the Cape de Verd Islands, having on board the first portion of the cable which the India Rubber, Gutta Percha and Telegraph Works Company is about to lay along the West Coast of Africa, as stated in the REVIEW for September 26th. Capt. E. Vasconcellas, of the Portuguese Navy, accompanies the expedition as representing the Portuguese Government. The *Buccaneer*, tender to the *Silvertown*, will proceed from the Cape Verd Islands in advance of the latter to survey and take soundings, having on board Mr. J. Y. Buchanan and Mr. Murray, who accompanied the *Challenger* expedition, and Mr. Rattray, the naturalist. A banquet was given on board the *Silvertown* before she started, at which were present Mr. Gray, the managing director of the India Rubber, Gutta Percha, and Telegraph Works Company (Limited); Count Ockza, who has conducted the negotiations between the company and the Portuguese Government; Major

Wood, the managing director of the Western and Brazilian Cable Company; Mr. Robert K. Gray, the engineer in chief to the Telegraph Works Company; Captain E. Vasconcellas, the representative of the Portuguese Government; Captain Hunter, R.N., of the West African Telegraph Company; Mr. James Sivewright, general manager of the Cape Government telegraphs, and many others. Mr. Gray proposed the healths of Her Majesty the Queen and their Majesties the King and Queen of Portugal. He stated that the latter had taken a great personal interest in this expedition, the result of which it was hoped would be to draw closer the bonds of union existing between Portugal and her colonies. Mr. James Sivewright, in responding for the Cape Government, said that Portugal was engaged with that Government in doing their best to carry civilsation into the Dark Continent. This line of telegraphic communication when completed would give England an independent telegraphic communication with India and Australia. Major Wood, in proposing "Success to the Expedition," said that the construction of this line of telegraph would stimulate trade in an enormous territory, the resources of which had hitherto remained undeveloped, but which would certainly before long afford a great market for British manufactures. Several other toasts having been given and responded to, those who were not going with the expedition returned to shore, and the *Silvertown* started upon her voyage, which is expected to last for four months, amid much cheering.

Mr. Cyrus Field on Cable Rates.— "Kiernan's Letter," an American news agency, makes public the following:—"Rumours of a probable reduction in cable rates having again arisen, we applied to Mr. Cyrus W. Field for information. Mr. Field says:—'I strongly advocate a reduction of cable rates to 6d. sterling per word for the public and 3d. for the Press. The matter will shortly be decided by the respective companies on both sides of the Atlantic.'"

It may be added that the *Financial News* has stated that Mr. Field has sold out all *his* cable stock.

The Antwerp Exhibition.—It is calculated that the Antwerp Exhibition will leave a clear profit of about 1,000,000 francs. The capital subscribed was 1,500,000 francs, to which the Government, in return for certain concessions, added a subsidy of 600,000 francs,

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Extension of an Electric Railway.—The electric railway, which has been in operation since April, 1884, between Moedling and Brühl, in the suburbs of Vienna, is about to be extended to Hinterbrühl; its length will thus be increased from 3 to 4·5 kilometres. The system adopted is that of Messrs. Siemens, by which the current is produced at a fixed point and transmitted to the motors of the cars by metallic conductors along the route. The power is at present generated by five dynamos, each giving 30 amperes, with a difference of potential at the terminals of 500 volts.

Electric Signals.—As fast as the double track of the Old Colony Railroad of New England is completed it is equipped with the Union Signal Company's block system of electric signals.

A New Primary Battery.—We understand that Messrs. Woodhouse and Rawson will shortly bring out a new form of primary battery, which is likely to prove of value for electric lighting purposes. The new battery is stated to be very easily maintained, and to be entirely free from the objectionable fumes which are emitted by nearly all, if not all, batteries which have hitherto been devised for similar purposes. The economy of the invention is stated to be such that a 15 candle-power incandescence lamp can be kept burning at a cost of ½d. per hour only.

The Thomson-Houston System.—The *Electrical World* in a recent issue states that the Thomson-Houston Company was practically unknown in England before winning the gold medal at the Inventories, the system never having been introduced here. The company sent over apparatus in charge of an electrical expert, and exhibited it purely on its merits. "The system was subjected to the most severe tests that could possibly be made to demonstrate the workings of the various important features which it possesses. On the first visit of the jury, they requested the expert to cut out lamps, twenty, twenty-five, and thirty at a time; to short-circuit the machines, pour oil on the commutators, and, in fact, do everything which would naturally tend to damage any dynamo machine. The jury comprised some of the greatest scientists of England, and the remarkable efficiency of the automatic features of this system, together with the fact that little or no depreciation could be discovered during a running period of ninety days, appeared to them in the light of a revelation. In their report upon the workings of the Thomson-Houston system, the jury say that from the time of starting up the lights to the day of submitting their reports there had been not one moment's cessation from any causes attributable to the machines or lamps. The fact that the highest honour in the gift of the commission has been bestowed upon the Thomson-Houston Company in the face of the strongest competition ever entered into at any electrical exhibition in which every prominent electric lighting company of Europe and the United States took an active part, speaks for itself. The award, which was the only gold medal given for arc lighting, was made on the 11th of August, at the London Inventions Exhibition Building, London, England."

Electric Boat.—We read that "a new electric boat has made a successful trial trip on the canal near Antwerp. The speed attained was 15 kilometres per hour."

A Bright Augury.—Sir David Salomons believes the first child to enter the world by the electric light is the son and heir born to him at Broomhill just before dawn on Tuesday.

Gas Explosion.—A light was taken into a room where the gas had been escaping in the City Road last week with the result that an explosion occurred, shattering the windows, setting the bedding on fire, and wounding a young man named Ware, who was conveyed to a surgery near.

Anglo-American Brush Electric Light Corporation, Limited.—We are informed that Major-General C. E. Webber, C.B., R.E., has joined the board of this corporation.

Book of Electrical Diagrams.—Mr. W. Lynd, Senior Principal of the West London College of Electrical Engineering, purposes preparing for publication a book of diagrams of Tests and Connections for the use of electrical engineers. The book will comprise "General Electrical Testing," "Telegraphic Apparatus," "Telephonic Connections," "Electric Light Engineering," "General Electrical Instrument Connections," and "Battery Grouping." The price of the work, which will be published by subscription, is fixed at 10s. 6d. We have some doubts as to whether this proposed work will actually "meet a long-experienced want" as Mr. Lynd imagines, *i.e.*, we doubt whether the want really exists. Diagrams are, of course, most essential, but they are of no great value without copious explanations to the majority of engineers, and if these explanations are given, the work becomes a book, and there are plenty of books with appropriate diagrams in existence. The work will undoubtedly have a certain value, but the latter is, we think, overestimated.

Maxim-Weston Electric Company, Limited.—We understand that this company has just completed a contract with the Government for the lighting of the Post Office Savings Bank, Queen Victoria Street. The original contract was for three gas engines of 40-H.P. indicated each, and 700 lamps. Finding, however, that the engines were capable of running a greater number of lamps than was originally intended, an alteration has been made in the installation, whereby the authorities will be able to run nearly double the number of lamps. The dynamos used are of the well known Weston shunt-wound type, similar to those used on board the *Gallia*; at Messrs. Rally Brothers, Manchester; and a number of other places. The lamp is the new Weston wavy filament. The tests on Wednesday were made in the presence of Mr. E. Graves, Chief Engineer Postal Telegraphs; Mr. W. H. Preece, F.R.S., Government Electrician; and other Government officials; and on behalf of the company there were present: Mr. Hugh Watt, Chairman; Mr. J. Buchanan Cox, Secretary, and Mr. J. J. Tough, Works Manager. After a test of several hours Mr. Preece, on behalf of the Government, expressed himself to the chairman of the company as entirely satisfied with the result. We are further informed that arrangements are now being made, by taking in an adjoining basement, to enable the plant originally intended to be largely increased. The principal new feature in connection with this installation was the steadiness of the incandescent lamps; the propelling power being gas engines. Hitherto such lamps have shown a disagreeable pulsation most painful to the eyes; but this company, in conjunction with Messrs. Crossley Brothers, have devised means whereby this has almost entirely been got rid of. We understand this is the largest plant of gas engines used for electric lighting that has yet been put down, and we are informed that the company is fully occupied with both home and foreign orders, and that excellent results have been obtained from the small dynamos specially designed for colliery work, which have been manufactured in this country, and wound and completed by the company's own staff. Electric lighting after many failures is, at least in the case of a few companies, assuming a practical commercial form, and a steadily growing business will no doubt result to those companies which, like the Maxim-Weston, take care to make their installations a success.

The Hell Gate Explosion.—Flood Rock was successfully blown out of existence last Saturday. Nine acres of rock had been pierced with four miles of tunnelling, and charged with over 300,000 pounds of explosives—dynamite, rackarock, &c. These were all connected by a battery, so as to be exploded by a single electric spark. The little daughter (eleven years of age) of General Newton, the chief engineer, pressed the button on the shore of Long Island which completed the circuit, and there uprose a mass of water nine acres in extent and 250 feet high. No damage was caused by the shock, which was felt all over New York and Brooklyn.

The Glasgow Fire Alarm System.—It was reported to the Glasgow Town Council that at a meeting of the Watching and Lighting Committee on the 18th ult., it was reported on behalf of the sub-committee, to whom the matter was remitted with powers, that the offer of Messrs. Anderson and Munro to renew and maintain the street electric fire-alarms and the A B C district fire-telegraph system had been accepted, the amounts being—for renewal, £1,220, and for maintenance during seven years from 21st October next, £240 per annum.

The Telephone and Police Work.—A smart capture is reported to have taken place at Portsmouth, a week or so ago. The chief constable (Mr. A. W. Cosser) received a telegram at his private address, requesting that a man who was "wanted" by the London police, and who was believed to be in the town, should be detained. Mr. Cosser, having certain information in his possession, at once telephoned to the Central Police Station, giving the clerk in attendance there instructions to speak through to the Buckland station, which is rather more than a mile distant, giving particulars as to the probable whereabouts of the man, and directing his arrest. The police had scarcely started on their errand when they met the "wanted" one, and, thanks to the expeditiousness of the telephone, were enabled, within ten minutes of the telegram being received, to acquaint the chief constable with the fact of his arrest. This incident demonstrates the great utility attaching to telephonic communication, so far as the police are concerned, and it can only be a matter of surprise that every police station in the Kingdom is not provided with such a thoroughly efficient mode of communication. At Portsmouth the various outlying stations have been in communication with the central station for several years past, and the latter is now connected with the offices of the Waterworks Company, whither news of an outbreak of fire is transmitted immediately on its receipt. Thanks to the telephone exchange, which has recently been established at Portsmouth by the Hants, Dorset, and South Wales Company, the police are now connected with many of the principal places of business and public institutions in the town.

Telephonic Communication with a Music Hall.—On the occasion of a grand performance at the Portsmouth Amphitheatre, telephonic communication was established between that place of amusement and a hotel a short distance away, and the listeners were enabled to hear with perfect distinctness everything that was said and sung on the stage; great satisfaction being expressed with the result of the experiment.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES

Lancashire and Cheshire Telephonic Exchange Company, Limited.—At an extraordinary general meeting of this company, held at 38, Faulkner Street, Manchester, on the 20th of August, it was resolved to increase the capital by the issue of 100,000 new shares of £1 each, to rank *pari passu*, and to be on a similar footing in all respects with the original shares (except as regards dividend which is to accrue proportionately as the shares are paid up), such new shares to be offered to the members of the company. This resolution was confirmed at a meeting held at the same place on the 7th ult., and was duly registered on the 19th ult.

Electric Sun Lamp and Power Company, Limited.—The annual return of this company, made up to the 6th inst., was filed on the 9th inst. The nominal capital is £200,000, in £5 shares; 7,750 shares have been allotted to the public and 16,500 to the vendors. Upon the former the full amount has been called up, and the latter are considered as fully paid. The calls paid amount to £38,071, leaving £724 unpaid. The total paid-up capital, including that portion represented by the vendors' shares, shows an increase of £8,890 10s., as compared with the previous return.

New Electro Amalgamator Company, Limited.—An agreement dated 5th inst. and filed on the 6th provides for the allotment of £250 in fully paid shares of this company to Mr. Francis Horner Lyell, of Nettlestone, Bickley, Kent, in consideration of the sum of £250 due to him by the Electro Amalgamator Company, Limited.

Liverpool Electric Supply Company, Limited.—The annual return of this company made up to the 27th of March was filed on the 8th inst. The nominal capital is £10,000, in £5 shares; 1,006 shares have been taken up, and £4 per share has been called thereon. The calls paid amount to £4,024, the paid-up capital thus showing an increase of £1,568, as compared with the previous return.

CITY NOTES.

The National Telephone Company, Limited.—This company announces an issue of 15,000 second preference shares of £10 each, which are entitled to a cumulative dividend of 6 per cent. per annum. The object of the issue is to provide for the development of the company's business. According to the accounts, the revenue remaining after payment of dividend has increased each year, and was, at the end of June, £5,980, of which £5,000 was carried to reserve. The balance of net revenue, after paying interest on debentures and the dividend on the preference shares for the year ended June 30th, 1885, was £12,807, which, it is stated is sufficient to provide for the present issue of second preference shares.

Lancashire and Cheshire Telephonic Exchange Company, Limited.—Letters of allotment have been forwarded to the shareholders with respect to the issue of 100,000 new shares of £1 each (1885). The dividend on the new shares (on which 4s. per share was payable on allotment, the remainder being called up as required) will accrue from November 1st next.

The Indo-European Telegraph Company, Limited.—The directors have declared an interim dividend for the half-year ended the 30th June, at the rate of 5 per cent. per annum, tax free, payable on and after November 1st.

Brazilian Submarine Telegraph Company, Limited.—At the general meeting, to be held on the 29th inst., the directors will recommend the declaration of a final dividend of 3s. per share, payable 30th inst., making, with interim dividends already paid, a total payment of 6 per cent. per annum for the year ended 30th June last. £12,000 has been transferred to the reserve fund from the profits of the half year.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 9th were £2,470, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

NEW PATENTS—1885.

11699. "Instruments for measuring electric currents." B. M. DRAKE, J. M. GORHAM. Dated October 1.

11707. "Instruments for controlling electric currents." O. E. WOODHOUSE, F. L. RAWSON, J. H. DAVIES. Dated October 1.

11767. "Electrical current measurer." H. F. JOEL. Dated October 2.

11788. "Electric meter." A. P. CHATTOCK. Dated October 3.

11812. "Secondary batteries." J. C. FULLER, G. FULLER. Dated October 5.

11813. "Holder for incandescent lamps." J. C. and G. FULLER. Dated October 5.

11822. "Circular telegram code." A. EMERSON. Dated October 5.

11850. "Preventing induction in telegraphy, telephony, and the like." W. L. WISE. (Communicated by J. Rae and J. C. Simpson.) Dated October 5.

11861. "Electric glow lamps." J. SWINBURNE. Dated October 6.

11876. "Making carbon filaments for electric lighting." F. V. HUGHES, C. R. CHAMBERS. Dated October 6.

11879. "Making metal covered electrical conductors." J. FATHAM. Dated October 6. (*Complete.*)

11887. "Electric signals combined with ordinary signals for collieries, mines, &c." J. J. RATHBONE. Dated October 6.

11943. "Special arrangement of the Wheatstone bridge as a resistance pyrometer." E. HARTMANN, W. BRAUN. Dated October 7.

11957. "Laying underground telegraph wires." W. A. JAMIESON. (Communicated by R. W. Jamieson.) Dated October 8.

12001. "Carbons for electric lamps." J. SWINBURNE. Dated October 9.

12005. "Telegraphic address book." S. REID. Dated October 9.

12015. "Dynamo electrolytic battery." R. ERISENMANN. Dated October 9.

12018. "Insulator for wires for electrical and other purposes." J. E. SPAGNOLETTI. Dated October 9.

12063. "Sodic bichromate constant current electric battery." F. S. FOWLER." Dated October 10.

12084. "Dynamo-electric machines." J. HOPKINSON, E. HOPKINSON. Dated October 10.

12096. "Regulating current or electromotive force of electric currrents." C. J. BOSANQUET, W. CAMERON, W. A. TOMLINSON. Dated October 12.

12106. "Electric apparatus for reproducing at a distance characters, signs and delineations. T. TUBINI. Dated October 12.

12110. "Telephones." R. H. RIDOUT. Dated October 12.

12170. "Galvanic battery." H. J. ALLISON. (Communicated by C. M. Gardner.) Dated October 13. (*Complete.*)

12181. "Electro-magnetic speed registers." B. FAYMONVILLE. Dated October 13. (*Complete.*)

12193. "Electric temperature regulators." W. P. THOMPSON. (Communicated by C. A. TUCKER. Dated October 13. (*Complete.*)

12205. "Regulating apparatus for arc electric lamps." C. DORNFELD, H. MULLER. Dated October 13. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

819. "An improved mode of making and breaking electric circuits." V. WILLIS. Dated January 20. 8d. Relates to an improved mode of making and breaking electric circuits, and thereby transmitting electrical impulses to a distance, and to various kinds of apparatus or mechanism from an operating piston, key, or lever, having a definite range of movement, the object in view being to make the apparatus or mechanism with which such circuit is connected respond promptly to each impulse transmitted to it, and to allow it sufficient time for recovering or resetting itself in readiness for promptly responding to another impulse.

4369. "Improvements in electric batteries." P. JENSEN. (Communicated from abroad by W. Hellesen, of Copenhagen.) Dated April 8. 2d. The inventor uses the oxides and superoxides of the heavier metals, and prefers to employ superoxide of lead where great intensity is required, oxide of iron ($Fe^2 O^3$) where economy is the chief point, or superoxide of manganese $Mn O^2$, which is about the medium between the two first named oxides. He employs these materials in the form of a fine powder, which said powder, when subjected to a powerful elastic pressure will remain in constant conducting connection with the cathode until the oxygen at hand is consumed. This is attained by surrounding the cathode with the said powder by means of a suitable fabric which is bound around the cathode or by attaching a strong porous cell or casing, for instance, of cellulose treated with sulphuric acid to the cathode and filling out the space between the casing and the cathode with one of the said powders, which is then hardly compressed, or the said cathode can be surrounded with powder in other suitable manner.

6529. "Improvements in and relating to electric time-pieces." W. P. THOMPSON. (Communicated from abroad by F. Baumann, of Waldenburg.) Dated April 14. 6d. The system of clock which forms the object of the present application for letters patent consists of a train of clockwork, striking mechanism, a balance weight, electrical contact pieces and an electro-magnet.

6574. "A new or improved system of cables or other conductors designed to suppress telegraphic and telephonic induction." R. TAMINE. Dated May 30. 6d. The inventor constitutes his lines by means of a central core, formed of a wire of iron or steel, or of a cord, or any other substance whatsoever. Round the core he winds in a contrary direction two conducting wires well insulated; he unites the opposite ends, those entering together and those going out together, and thus obtains a cable which prevents the hearing of conversations, sounds, and noises, resulting from the induction phenomenon from line to line.

7338. "Improvements in electric motors." C. A. JACKSON. Dated June 16. 6d. Consists essentially in the peculiar adaptation of a crank to a driving shaft, whereby an increased length of crank is obtained with but a minimum traverse or throw of the armature.

7638. "Improvements in electric bells." H. B. PORTER. Dated June 23. 4d. Relates to certain novel and useful improvements in electric bells, and has for its object to improve on the construction shown in United States Patents Nos. 214261 and 261172, granted April 15, 1879 and July 18, 1882.

8076. "An improved electrical conducting material." C. S. BRADLEY. Dated February 24. 4d. Consists of gas-retort carbon, or its equivalent, and gutta percha or india-rubber. The ingredients of the composition may be used in various proportions, and various methods of mixing them may be employed; but the inventor has found that excellent results are obtained in the following way: He takes from 1 to 10 parts of finely ground gas-retort carbon, and 1 part of gutta-percha or india-rubber, and thoroughly incorporates these ingredients by rolling in the well-known manner in which gutta-percha and rubber are usually worked. The mixture having been properly made, the resulting material may then be pressed into the required form in suitable moulds, it being made plastic for this purpose by slightly heating it. In order to harden and strengthen the material, it may be vulcanised by any of the well-known processes employed for gutta-percha and rubber.

CORRESPONDENCE.

Lightning Conductors.

It appears to me incumbent on the erectors of lightning conductors to obtain the best earth that can be found in the vicinity of the buildings; for if this precaution is not taken the lightning may find an easier path to earth than through the conductor erected for its discharge, viz., through the building, attended either with or without dislocation of the structure. This bears on your correspondent, Mr. Geo. Driver's remarks, in the October 3rd number of the REVIEW, in regard to striving after ·25 of an ohm as an earth, which no doubt is very low, and perhaps obtainable only where a very extended metallic area is available, such as the system of water pipes I connected to. Only where no such mass of metal is to be found, should an earth of high resistance amounting to the late Mr. Robert Sabine's limit of 20 ohms be left, and then only if there was no lower earth near.

I base these considerations on the fact that lightning takes the road of least resistance for its discharge, viz., either through the conductor or through the building, or probably darting from one to the other and making use of each.

The conductivity of that part of the building within the area of the discharge, may not be inconsiderable when its extent and mass are compared with the sectional area and weight of the conductor; and, further, the earth of the building through the foundation, which has a large earth surface carried down into the dampest ground, is much greater in area than that of the copper plate at the end of the lightning conductor.

These two factors taken together may bring the total conductivities to earth of the rod and of the building nearer together, so that there will not be the great difference of route for the lightning to follow. Hence the desirableness of securing an earth for the copper conductor of low resistance, whether by water mains or otherwise.

I may point out that a damp-proof course of asphaltum on foundations would tend to insulate a building and to direct the course of a lightning flash through the conductor. It would be interesting and afford practical knowledge of the dispersion of atmospheric electricity if measurements were made of the resistance of masonry between surfaces on the upper part of the buildings and earth, for in modern structures in which iron is largely used, the surface in contact must be large, and the conduction of the masonry consequently greater than formerly. Thanking you in anticipation for the insertion of this letter.

E. W. Beckingsale.

London, *October 8th*, 1885.

Reis's Telephones.

Your correspondent "G. R." is apparently trying to cover his retreat by abuse, and by ingenious suppression of essential portions of the sentences which he is professing to quote. The point which I had been urging was this: that Reis's deliberate and express intention was to devise an instrument to transmit human speech, not musical tones only; and *I proved this intention* by quoting from Reis's own memoir of 1861. That memoir mentions in the frankest possible manner that though the consonants were tolerably well rendered by the telephone, the vowels were not; and Reis himself expressly said at that date (1861): "Until now it has not been possible to reproduce human speech *with a distinctness sufficient to satisfy everybody*." Taken in its entirety, the sentence proves the inventor's intention beyond all question, and it also proves a certain degree of success. He intended it to transmit speech, but was puzzled to find that the first rough telephone which he constructed did so only very imperfectly.

Now what does "G. R." do with these remarkable words? He knows that this sentence proves my point, and that if he had quoted it honestly it would have disproved his argument. So he coolly suppresses the words which I have italicised above, and thereby changes the bearing of the sentence. "G. R." must know that such a suppression of essential words is a flagrant piece of literary dishonesty. It is well for himself that he chooses to give initials only. He dare not sign his name to such a fraud as that which bears his initials in ELECTRICAL REVIEW, October 3rd, 1885, p. 304.

This is what "G. R." writes:—

"Prof. Thompson makes Reis say himself: 'Until now it has not been possible to reproduce the tones of human speech, &c.' Why try to prove that he did by faulty translation, or declaring a horse chestnut to be a chestnut horse?"

To this I reply:—

First. I have not "made" Reis say anything; for the words here partially quoted are Reis's own, published in 1861.

Second. The suppression of the words that should stand in the place of "G. R.'s" "&c." is a dishonest fraud, because thereby the whole bearing of the sentence is altered.

Third. The accusation of faulty translation, coming as a mere unproved assertion from "G. R." needs neither reply or comment; for the only fault in the translation is the suppression of words of which "G. R." is guilty.

Lastly, I wish to point out another literary fraud. "G. R." in describing what "Dr." Reis's instrument was said to do (Reis was not "Dr;" that honour was refused him under circumstances I need not here recount), says that it could amongst other things "Lante von sich gebend." He puts these four words into quotation marks so as to make the reader suppose that they are a genuine quotation from Reis's memoir. If I am not mistaken these four words are nonsense. "Lante" should be "Laute," and "gebend" should rather be "geben," if the sentence is to have any correct meaning. But I pass over these little errors. The important point is that no such words are to be found in any of Reis's writings. To invent a sentence, and to dress it up in quotation marks in such a way as to make the reader think that they are not the writer's own, is dishonest to the last degree. It is a trick worthy of the crew who persistently decry the deceased inventor's merits.

Silvanus P. Thompson.

Finsbury Technical College,
October 7th, 1885.

Magnet Steel.

I notice in your correspondence columns this week a letter headed as above, in which the writer asks for the address of a firm whose steel is suitable for permanent magnets.

I may mention that for magnets of small size, such as are used in Spagnoletti's and other induced single needle dials, I have found no better than a sample of diamond cast steel, supplied by Spencers, of Rotherham. But this is of a decidedly close and not a porous nature, for which reason, if no other, I would recommend it, as I find that steel of this nature, if properly tempered, when saturated retains its charge longer, and is more constant than the more porous kinds, although probably it is not capable of absorbing quite as strong a charge.

F. W. Cooke, A.S.T.E. & E.

Retford, *October 12th*, 1885.

Swan Lamps.

The letter of your correspondent "Please" in your last week's issue is written under a complete misapprehension. We do not profess to supply lamps which "only require 2·5 watts per candle." As lamp manufacturers on a large scale, we know that length of life of the lamp is the most important consideration in the minds of our customers, and we do not sacrifice durability to an imaginary efficiency.

S. Flood Page, *Secretary,*
The Edison and Swan United Electric Light Company, Limited.

57, Holborn Viaduct, London, E.C.,
October 14th, 1885.